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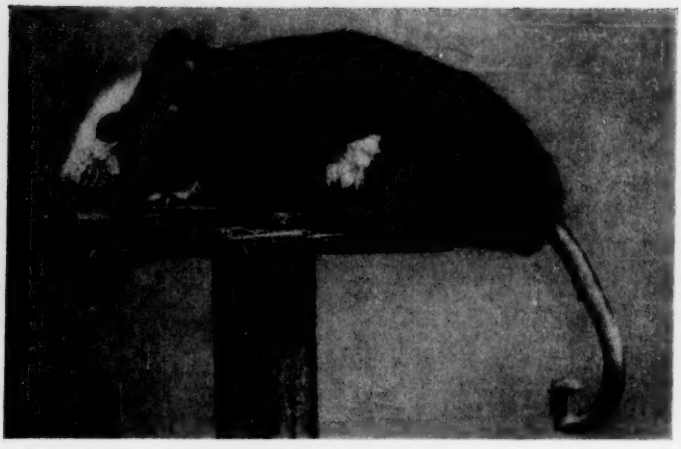

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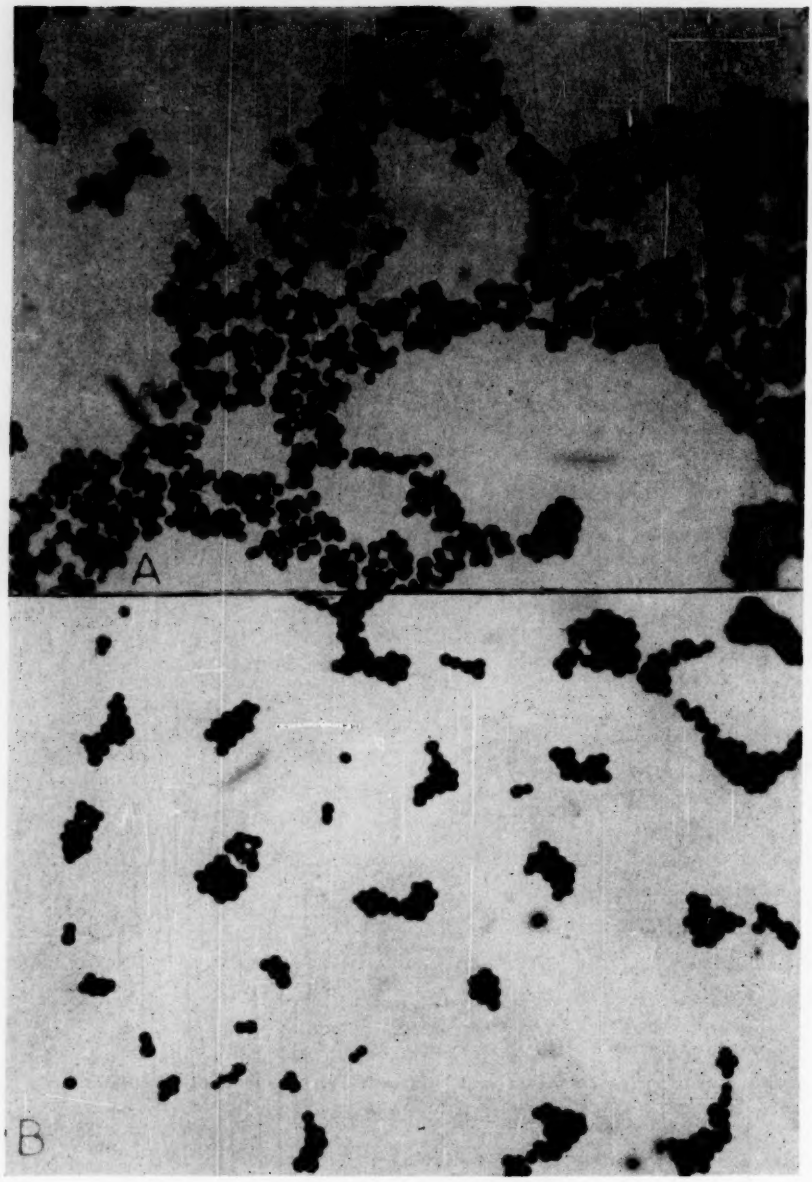


NORMAL AND VARIANT COLONIES

Figure 1

Photomicrographs of cultures of normal *Sarcina lutea* (*A*), and of the variant, *S. lutea* var. *alba* (*B*). Both photographs are of 24 hour cultures and show physical arrangement and size of the cells. The mutant form, lacking pigmentation in addition to the other differences, can be induced by several different treatments. Gram stain, ×2100.

A PRELIMINARY INVESTIGATION OF MUTATION PRODUCTION

In *Sarcina lutea* Schroeter*

CONCETTA CATHERINE BELLINI†

Biological Laboratory, Fordham University, New York

IT HAS been frequently demonstrated that variations in bacterial pigments occur spontaneously under ordinary conditions of cultivation and that they are also induced experimentally by modifications in the composition of the culture medium, by alterations in the PH or temperature of the medium, by the addition of various chemical substances to the culture medium, by growing various species together, and by the use of such agents as bacteriophage, irradiation, and antibacterial drugs. The advantages of working with pigmented species in the study of bacterial variations have been recognized by many. However, our knowledge of the heredity of pigmentation in bacteria is limited, for observations must be made upon colonies rather than upon individuals.

The present study was undertaken to investigate a white mutant of *Sarcina lutea* which was regularly recovered whenever it was grown with *Bacillus subtilis, Bacillus megatherium,* and *Proteus vulgaris.* In addition to the yellow colonies of *Sarcina lutea,* there was consistently noted the occurrence of white colonies which bred true. Other experimental methods to induce the transformation of the chromogenic micrococcus, *Sarcina lutea,* into a non-chromogenic type were likewise employed. During the course of this study, experiments were performed to determine: (1) the rate of spontaneous mutation in pure cultures of *S. lutea;* (2) the effect of growing *S. lutea* together with several other bacterial species, and then successively omitting first one and then two of the three bacterial species initially used; and (3) the effect of growing *S. lutea* in autoclaved broth cultures in which the initial mixture of bacterial species had been allowed to grow, either collectively or singly.

Other Experiments

Conn[10] isolated and described a culture of *S. lutea* in which the color of the colonies varied from a milk-white to a deep orange. By continued platings, he was able to obtain pure white and pure orange strains which remained constant for nearly three years. He concluded that such variations were to be compared to mutations obtained in higher plants. Oliver[15] noted color changes in *S. lutea* when grown in the presence of various salts and dyes. Wolf[19] grew colonies of both *S. lutea* and *Serratia marcescens* in media containing minute quantities of various salts such as potassium permanganate, cadmium nitrate, and potassium bichromate. He obtained white races which never reverted to the normal type even after prolonged growth in normal media. Beijerinck[4] studied several species of *Sarcina* and induced the production of stable white colonies by growing cultures upon malt agar.

The principal method of inducing the mutation obtained in this study has been by growing *S. lutea* together with other bacterial species. With the exception of experiments concerning pneumococcus type transformations, there have been few studies on the direct hereditary interaction of one bacterial type with another. Alexandre and Cacchi[1] in a study of mixed populations consisting of two different species, found that originally S-type typhoid-paratyphoid organisms demonstrated a marked tendency to produce R-type colonies,

*Abstracted from the dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Biology at Fordham University, New York, 1949.

†The author wishes to acknowledge the assistance of Dr. E. R. Witkus, under whose guidance this investigation was conducted.

after growth in association with *Lactobacillus bulgaricus*. Lederberg[12], Lederberg and Tatum[13] and Tatum and Lederberg[18] have presented evidence for the occurrence of character recombinations in mixed mutant cultures of *Escherichia coli*. They interpreted their results in terms of gene recombinations though they did not exclude the possibilities of the presence of either a transforming principle or an unknown factor. McCarthy, Taylor, and Avery[14] succeeded in transforming nonencapsulated *R* (rough) variants, derived from one specific type of pneumoccoccus, into encapsulated *S* (smooth) variant type cells. This was accomplished by growing the nonencapsulated cells in a special serum broth to which the active principle, extracted from the encapsulated pneumococci, was added. Avery, MacLeod, and McCarthy[3] found this transforming principle to be a specific desoxyribose nucleic acid. Boivin[5] and Boivin and Vendreley[6] reported a similar transformation involving the capsule of a strain of *S. coli*, by utilizing an inducing principle of a desoxyribose nature from a bacterium whose genotype was desired.

Materials and Methods

The American Type Culture Collection Strains of bacteria were used in this investigation. The principal strains employed were *Sarcina lutea, Proteus vulgaris, Bacillus subtilis,* and *Bacillus megatherium.*

Nutrient agar was the medium used for the plating and subculturing of the bacterial species, and nutrient broth was used for growing all bacterial cultures. The dilution method was employed to insure the isolation of discrete colonies and pure cultures of the various bacterial species. Only 24-hour-old cultures of the test organisms were used in each experiment. The environmental conditions were carefully recorded in each experiment.

The presence of white colonies of *S. lutea* was detected by inspection. Gram-stained slides were prepared of organisms obtained from the white colonies. In each case, detailed microscopic examinations followed the isolation of the white colonies, and all microscopic studies were made with the oil immersion lens.

The mutant strains were subcultured on nutrient agar slants at two-day intervals covering a culturing period of two years. The macroscopic colony count method was used to determine the number of yellow and white colonies, and as each series of experiments was conducted, the ratio of parent-type (yellow) and mutant-type (white) colony occurrence was estimated. It was thus possible to compare the relative occurrence of spontaneous and induced mutations.

It was considered advisable not to discard the inoculated plates immediately after initial observation, for it was found that interesting changes often accompanied prolonged growth on agar. Therefore, the plates were kept at 37°C. for the first 24 hours, and thereafter at room temperature for a maximum period of one month.

Experimental Results

The spontaneous pigment mutation of *S. lutea* in pure culture was observed to occur at a rate of about one white colony in 40,000 yellow colonies. When *S. lutea* was grown in a mixed bacterial culture containing the three species, *B. subtilis, B. megatherium,* and *P. vulgaris,* five different bacterial strains instead of four, were consistently recovered. The one additional strain recovered in all cases was the glistening porcelain-white colony of *S. lutea,* referred to here as *S. lutea* var. *alba.* The rate of the occurrence of a white mutant colony of *S. lutea* when grown in this mixed culture was thus estimated. This experimental procedure was repeated 15 times and each experiment was performed in duplicate. In order to ascertain whether a mixture of all three bacterial organisms was necessary to induce the appearance of a white colony, *S. lutea* was cultured with the same bacterial organisms as above, but this time successively omitting first one and then two of the initial bacteria used. In each case, the rate of the occurrence of a white mutant colony of *S. lutea* was estimated.

Several different bacterial mixtures, other than the initial combination of organisms, were grown with *S. lutea* in an effort to ascertain whether the particular mixture used initially represented the only possible medium leading to the production of white colonies of *S. lutea.* In each case, the rate of the occurrence of a white mutant colony of *S. lutea* was estimated. In an effort to ascertain what the principal factor or factors might be in stimulating the appearance of the white colonies of *S. lutea* when grown in a mixed bacterial culture, the following procedure was likewise employed. *S. lutea* was cultured with *B. subtilis, B. megatherium,* and *P. vulgaris* in nutrient broth incubated at a temperature of 37°C. for 24 and 48 hours respectively. Following these incubation periods, the cultures were autoclaved at 15 lbs. pressure for 20 minutes on two consecutive days so that they were sterile. Each of these autoclaved cultures was then inoculated with a 24-hour-old culture of *S. lutea,* and after incubation periods at 37°C. for 24 and 48 hours, the culture contents were isolated by the dilution method. The effect of growing *S. lutea* in the single autoclaved cultures of *B. subtilis, B. megatherium,* and *P. vulgaris* was also studied, and the ratio of white to yellow colonies resulting from the application of this procedure was estimated.

The rates of the occurrence of *S. lutea* var. *alba* following the application of the several different experimental methods employed appear in Table I.

Cumulative Effects

The rate of the occurrance of a white mutant colony of *S. lutea* when grown in a mixed bacterial culture was, therefore, found to be very much greater than the spontaneous pigment mutation rate. It was likewise observed that cultures containing a mixture of all three bacterial organisms showed a higher rate of pigment mutation than did the cultures containing only one or two of these organisms. White colonies were recovered in all cases and there was a notable increase in their frequency as compared with the rate of their spontaneous occurrence. Also, the several diverse bacterial mixtures, other than the initial combination, grown together with *S. lutea* were observed to lead to the production of white colonies at frequencies exceeding that of their spontaneous occurrence. The ratio of white to yellow colonies resulting from the use of autoclaved bacterial cultures was found to be greater than that occurring spontaneously. Further, the rate of the occurrence of a pigment mutation of *S. lutea* when grown in the mixed autoclaved cultures was found to exceed that occurring when *S. lutea* was grown in the single autoclaved cultures. An increase in the number of both the white and yellow colonies was noted with a corresponding increase in the length of the incubation time.

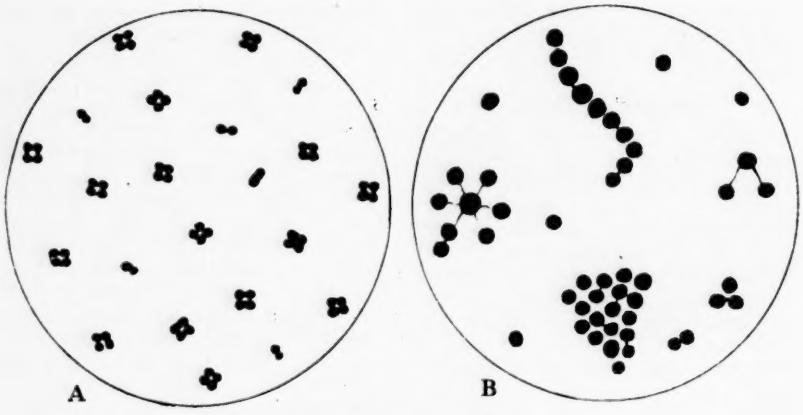
The white form of *S. lutea* was observed to be stable, there being no evidence of spontaneous reversion to the parent-type throughout the course of cultivation, nor as a consequence of any special methods employed to induce such a reversion. When *S. lutea* var. *alba* was cultured with *B. subtilis, B. megatherium,* and *P. vulgaris,* only these four strains were recovered, there being no yellow colonies recovered. As evidence of the stability of the white form of *S. lutea,* there was no reversion of the mutant form to parental type, even after subculturing the white form at 48-hour intervals for a period of two years.

The time of the appearance of the white and yellow colonies after plating was found to vary. In certain of these experiments, the appearance of the white colonies was observed within 24 hours after inoculation of the agar pour tubes, there sometimes being yellow colonies present at that time. In other instances, 100 percent yellow colonies were recovered within 24 hours after inoculation, no white colony being noted until after there had been a prolonged incubation period at room temperature. This was the most usual result obtained. The result of still other experiments consisted in the simultaneous appearance of the yellow and white colonies. An increase in the length of the incubation period was observed to be associated with a parallel increase in the number of white colonies obtained.

The white colonies of *S. lutea* thus derived by several different experimental procedures were found to be identical to, or at least, indistinguishable from each other and from the white colonies arising spontaneously.

TABLE I. The ratio of white to yellow colonies obtained when *Sarcina lutea* was grown with other bacterial organisms.

Organisms grown in association with *Sarcina lutea*	Ratio of white to yellow colonies *24* hrs.	*48* hrs.	*120* hrs.
None	1:40,000	.....	.....
B. subtilis, B. megatherium, P. vulgaris	1:4	.....	.....
B. megatherium & P. vulgaris	1:7	1:6	1:5
B. subtilis & P. vulgaris	1:7	1:5	1:5
B. subtilis & B. megatherium	1:7	1:5	1:5
B. subtilis	1:25	1:21	1:18
B. megatherium	1:27	1:20	1:18
P. vulgaris	1:28	1:20	1:20
B. subtilis, B. cereus, & Corynebact. xerose	1:8	.....	.....
B. subtilis, B. cereus, & B. coli	1:9	.....	.....
B. megatherium, B. cereus, and *B. coli*	1:10	.....	.....
B. subtilis, B. coli, & Corynebact. xerose	1:7	.....	.....
B. megatherium, P. vulgaris, & Corynebact. xerose	1:7	.....	.....
B. megatherium, P. vulgaris, & B. cereus	1:7	.....	.....
S. lutea grown in autoclaved broth from:			
B. subtilis	1:25	1:24	.....
B. megatherium	1:27	1:25	.....
P. vulgaris	1:30	1:26	.....
Mixed autoclaved cultures	1:7	1:6	.....



MUTANT CELLS LARGER

Figure 2

The normal cells (*A*) range from 1 to 1.5 microns in diameter, and mutant cells (*B*) from 3 to 3.5 microns. Diplococci were observed in normal colonies, while in mutant colonies staphlococcic and streptococcic formations were observed.

Description of Colonies

The agar plate colonies of both the white and yellow forms were observed to have a circular shape, smooth surface, raised elevation, entire edge, and were seen to be opaque. Abundant growth on nutrient agar slants was noted in both the white and yellow cultures. When grown in nutrient broth, both the mutant and parent cultures were observed to have moderate growth and the organisms were seen to settle at the bottom of the tubes. The parent and mutant cultures were seen to differ in only two cultural characteristics, namely in their relative viscosities and in their chromogenicity. The parent culture has a chrome-yellow pigment, whereas that of the mutant culture is white. The mutant culture was observed to have a more pronounced degree of viscosity.

Both organisms were found to be gram-positive. In only two instances, the initial reaction of the mutant colonies was found to be gram-negative, the positive reaction being restored within the subsequent 24 hours. Also, an occasional appearance of smaller, gram-positive bodies was noted within the larger, gram-negative cells comprising the mutant colonies. No definite conclusion was drawn regarding this.

The mean size of the parent cells was found to range from 1.0 to 1.5 μ (Figures 1*A* and 2*A*), whereas the mean size of the mutant cells was found to range from 3.0 to 3.5 μ (Figures 1*B* and 2*B*). The most typical cell configuration observed in the parent colonies was that of a regular formation of cuboidal packets of eight or more cocci, uniform in size. Diplococci were also noted (Figures 1*A* and 2*A*). Commonly observed cell configurations of the mutant colonies were the staphylococcic and streptococcic formations, and that of a single, central, larger sphere connected by apparent strands to several smaller daughter cells which seem to be budding out from the parent cell (Figures 1*B* and 2*B*). In connection with these observations regarding typical cell configurations, it was observed that transverse fission predominated as the apparent means of reproduction in the parent colonies, budding being noted to a much lesser extent. Whereas, budding was observed apparently to be the predominant means of reproduction in the mutant colonies, with evidence of transverse division also present to a lesser degree.

Discussion

The white colony type is considered to be a mutant form of *S. lutea*, and it is contended that the mutant form has been induced by the several different cultural methods used here since the frequency of the pigment transformation was increased as a consequence.

Several investigators have shown that the products of one bacterial species are capable of influencing the structure and behavior of another species grown in as-

sociation with it. In the present study, a certain analogy can be made. However, it must be pointed out that all such experiments have been concerned with varied strains of one bacterial species, whereas in this study, entirely different species were involved. Since sexual reproduction between different bacterial species has not been known to occur, the more probable interpretation would be the presence of a transforming principle.

More recently, Fries[11] conducted some experiments concerning the production of mutations by caffeine in the fungus *Ophiostoma multiannulatum*. The chief aim of his paper was to elucidate whether the caffeine effect, namely the production of monoconidial mutant mycelia, was due to selection or to mutagenesis. He claimed that irrespective of the medium used for the inoculation culture, no significant qualitative or quantitative differences could be found between the mutant yields of the various caffeine-treatment experiments, nor were these yields different from those of ultraviolet irradiation experiments. Fries claims such facts can be understood only by assuming a mutagenic activity of caffein. However, he also asserts that a certain selection in favor of pre-existing mutant conidia may operate in single instances, through it must account for an insignificant part of the caffein effect.

The mutation reported here has been shown to be stable, never reverting to the parent-type either spontaneously or as a consequence of any special methods used to induce such a reversion.

No conclusive statement can be made in reference to the time of the appearance of the mutant, since, as was stated previously, no regular pattern was observed. Reed[16], in a study of the color variants of *Serratia marcescens*, found that a common occurrance was the delayed appearance of the color variants which were sometimes observed 24 to 36 days after inoculation. Zamenhof[20,21] contended that a certain amount of time must elapse before the medium becomes preferential for the eventual appearance of the mutant. It seems to be a common occurrence in many studies of bacterial mutations and it is not adequately understood.

A comparative study of some cultural characteristics of the parent and mutant forms led to the conclusion that they were fundamentally similar, with the exceptions of color and viscosity. Reimann[17] in a study of the color variants in cultures of *Micrococcus tetragenus*, found that color varies independently from colony type and that both are inherited independently of presence or absence of capsules. Reed [16] and Bunting[7,8] have shown that the inheritance of color in *Serratia marcescens* occurs independently of capsulation or colony type. Byatt, Jann, and Salle[9] maintained that the chromogenic culture derived from the white *Staphylococcus aureus* strains retained all the biochemical properties of the parent culture, with the exception of pigment production.

It was concluded that binary fission was the most frequent apparent means of reproduction in the parent form, whereas budding was the predominant one in the mutant form. Appleby[2] found that the most common type of reproduction in the *Sarcinae* was binary fission, but he also gave evidence that budding could likewise be found to occur.

Although the mutation can be explained in terms of the selective survival of spontaneous mutations, the greater probability that the white forms represent results of an induced mutation is supported by the above results. Therefore, there appears to be a heat-stable factor produced in broth by certain organisms which either selects for the non-pigmented strain of *S. lutea* or induces change to this form, since the factor was not destroyed by autoclaving.

Summary

In the micrococcus organism, *Sarcina lutea*, Schroeter, a non-pigmented mutation was obtained and has been referred to as *Sarcina lutea* var. *alba*. It has a porcelain-white rather than a chrome-yellow pigment. The new color form is probably an induced mutant form al-

though the possibility that it represents a selective survival of spontaneous mutations has not been ruled out.

Several experimental methods were successfully employed to induce the appearance of the white form, and in each case, there was a notable increase in the frequency of the white form as compared with the rate of its spontaneous occurrence. The principal method used was the growing of *S. lutea* together with *B. subtilis, B. megatherium,* and *P. vulgaris.* Other methods used were the growing of *S. lutea* in diverse bacterial mixtures and the growing of *S. lutea* in autoclaved broth cultures in which the initial mixture of bacteria had been allowed to grow.

The mutant-type colonies derived by each method were found to be apparently the same, or at least indistinguishable from one another and from the spontaneously-derived mutant forms, with respect to some properties tested.

No reversion occurred spontaneously during the course of cultivation, or was ever induced by any procedure used, in a period of two years. Evidence was presented for the stability of the mutant forms.

Continued investigation should lead to more definite statements concerning the mechanisms involved in pigment mutations in bacteria.

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◆

Michurinism in Lithuania

THE State Publishing House of Political and Scientific Literature late in 1950 published a 146-page book, *"Svietimas Tarybu Lietuvoje"* (Education in Soviet Lithuania), edited by the present nominal "Minister of Public Instruction," comrade Albertas Knyva, and his predecessor in office, comrade Juozas Ziugzda. Other contributors were I. Ariskin'as, J. Bucas, A. Gucas, J. Lauzikas, E. Lisauskas, J. Salkauskas and V. Uogintas. 5.000 copies were printed for retailing at 1.45 rubles per copy.

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"The teaching of natural science, based on the Michurin science, strives to give the student the firm, logical, systematic information of the basic Michurinite biology, to open to students the vista of the principles of the animal and plant life, and in this manner, to help them in forming their scientific world outlook, based on dialectical materialism.

"Botany, zoology, human anatomy and physiology together with the principles of Darwinism, literature, history, constitution, help develop in young Soviet citizens the materialistic ideology and communistic morals."

—J. Kelvytis. *Lithuanian Bulletin,* Vol. IX, nos. 1-6, January-June 1951. New York. pp. 9 and 12.

"COLLEGE MEN AND THE BIRTH RATE"—25 YEARS AFTER*

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IN 1926 the *Journal of Heredity* reported a study conducted by Stuart Rice and Malcom Willey of the number of children desired by a group of college undergraduates in 1925[7]. The participants in the study, all students at an eastern college, were asked to reply anonymously to this question: "In your day-dreams of marriage, do you visualize children; if so how many?" The authors reported that "seven only of 90 men to whom the question was put stated that they had no such day-dreams. Of the remaining 83, 82 admitted a visualization of children. One man only expressed a desire for a childless marriage. Three were indefinite concerning the desired size of their dream family, but the remainder were specific." The distribution is shown in Table I. The average family size desired was 2.6 children.

The Family Achieved

Did this group of men have the number of children they wanted when interrogated in 1925?† To answer this question the best method would have been to find the names of the students who answered the 1925 questionnaire. Then one could find out the size of their families from the files of the College's Alumni Records Office. Unfortunately, this procedure could not be followed because the replies to the questionnaire were anonymous[7].

Our method of investigation has followed an alternate path. Since Rice and Willey have stated[8] that the participants in their study were students in the sections of introductory Sociology taught by them during the fall semester of 1925-1926 it became possible to know what group of men *could* have been polled in 1925. From the academic record cards on file in the Registrar's Office at the college we secured a list of the men who took introductory Sociology during that semester. They were 445 in number. Since students were assigned to sections by the Registrar, and not in terms of any criteria which we believe could affect the results of our study, we have assumed they were distributed at random. In terms of this assumption, the respondents in the 1925 study can be thought of as a random sample of the total registration of 445 students, and therefore identical, for our purpose, with any other random sample drawn from the total. Figuring in this manner, we drew at random a 20 percent sample.

TABLE I. Distribution of wanted children, 1925.

No. of Children desired	No of men
0	1
1	2
2	38
2 or 3	9
3	15
3 or 4	3
4	6
4 or 5	1
5	3
5 or 6	1
10	1
	80

*This study was completed with the aid of a grant from the Dartmouth College Committee on Research and with the invaluable assistance of Richard Reed, Dartmouth '51.

†Only a single previous study is known to us which compares the number of children desired by a group of college graduates with their achieved fertility—C. D. Dennison's study of 400 Princeton alumni[1]. Dennison's study differs from ours in one significant respect: he polled his respondents about how many children they wanted *after* they had already completed their families. He discovered that his subjects had had an average of 2.4 children, but that in retrospect, they would have liked to have had an average of 3.9 children.

or 89 men, from the list of 445 men who took introductory Sociology during the autumn of 1925-26. We have investigated the achieved fertility of this sample, and because both this group and the participants in the 1925 study were random samples, we assume this investigation has disclosed the achieved fertility of the men interrogated by Rice and Willey 25 years ago.

Information about the fertility of the graduates was obtained from the extensive files of the College's Alumni Records Office. If the data in the files were incomplete for any individual we mailed him a return postal card requesting the relevant information.

The Responses

The files and postal cards yielded information about 78 of the original sample of 89 men.* Of the 78 men in the sample, 70 were married. Of the eight single men, three died within five years after leaving college, and five remain bachelors today. The average age at marriage for the group was 29 years. Of those men who had one child or more, the fathers averaged 32 years of age when the first child was born.

Seventy-two men of the total sample of 78 are still living. Of the deceased six, three lived long enough to get married and have the opportunity to complete their families. Two of the six men who are now dead died by suicide.

Table II compares the number of children wanted by the respondents in 1925 who had day-dreams of children with the achieved fertility by 1950 of the 70 men *who married*.

The discrepancies shown in Table II are striking†. About sixteen percent of the group has had no children, although only one in a hundred wanted a childless marriage when they were interrogated twenty-five years ago. Six times as many men as wanted only one child have had one child. The number of two, three, four, and five-or-more child families is less than was anticipated. The individual who accounts for the one percent figure in the five-or-more category is a graduate who is the legal father of seven children, but the biological father of only four of them; the other three were contributed by his second wife from her first marriage. The average of 1.9 children per graduate means that the group achieved a fertility less than ¾ of the average family size to which they aspired in 1925. Although the discrepancy between aspiration and achievement for this group of men is striking, their achieved fertility itself is not unusual for men who graduated from college during the 1920's. If we include the eight single men covered by the study in our calculations, the average fertility of the group is 1.6 children. This rate is close to the average fertility rate of 1.72 for the men (married and

TABLE II. Distribution of wanted children (1925) and of achieved children (1950).

Number of children	Percentage of graduates who wanted stated number of children in 1925*	Percentage of graduates who achieved stated number of children by 1950
0	1.0	16.0
1	2.5	16.0
2	56.0	43.0
3	24.0	17.0
4	10.0	7.0
5 or more	6.5	1.0
Average	2.6 children	1.9 children

*The second column of Table II is adapted from Table I. Following the procedure generally accepted among the "pollsters" we have split the "either-or" responses in Table I according to the proportions of the definite responses in Table I. For example, 2½ as many respondents who wanted three children wanted two children. Therefore, we added 5/7 of the total of 9 "2 or 3" respondents, or 6 respondents, to the 2 children category, and 2/7, or 3 respondents, to the class of those wanting 3 children.

*On the basis of the experience of various colleges with their graduates it may be suggested that the 11 men about whom we have no relevant information probably are among the poorer and less successful members of their college classes. It is such individuals who try to sever their relationship with the College in order to avoid its periodic solicitation for funds.

†Assuming the two samples, 1925 and 1950, are not correlated, the difference between the means is significant at the 1 percent level of confidence. $T = 3.9$. If the samples were correlated T is likely to be larger still. Therefore, there is little reason to doubt that the difference between the means is a real difference.

single) in the 1922 classes of 35 colleges tabulated in Gamble's[2] study. The size of the families in our sample is larger than the size of completed families in which the husband had four years or more of higher education, as reported by Kiser and Whelpton[3] in the published accounts of their Indianapolis study.

In only one respect were the desires expressed in 1925 a good index of the fertility achieved by 1950: very few respondents wanted and very few achieved families of more than three children. Another way of expressing the relative accuracy of the 1925 study in predicting the maximum fertility of the group by 1950 is as follows: (a) 3.5 percent of the 1925 sample wanted one child or less, but 32 percent had one child or less; (b) 59.5 percent wanted two children or less but 75 percent had two children or less; on the other hand, (c) 83.5 percent wanted no more than three children, and 92 percent had no more than three. The discrepancy between aspiration and achievement in case (a) is 800 percent; in (b) 25 percent; but in case (c) it is only 10 percent.

It would be interesting to know why the achieved fertility is so much less than the men desired in 1925. Unfortunately, the information available about the alumni is not sufficiently abundant to yield an adequate explanation of this result. However, there is evidence of a sort which confirms the part played by three factors: impaired fertility, contraceptive practice, the effects of the depression and economic insecurity. These factors are discussed below, but no attempt can be made to assess their relative importance in causing the discrepancy.

Relative Fecundity

We lack physiological evidence of the relative fecundity of graduates or their wives, but the existance in some cases of impaired fecundity seems the best way to account for the large proportion of successful graduates who are childless, particularly since we know that economic security and voluntary childlessness are inversely related*. Of the 11 childless men, four are professionals: a teacher, two lawyers, an architect; three are in top positions in business: one is the owner of a large clothing manufacturing concern and holds the highest office in the legislature of his state, another is the advertising director of a national food products firm and the third is a certified public accountant and treasurer of one of the large American baking products businesses. The only segment of the sample to have as large a proportion of successful men is made up of the graduates who have three children.

Contraception

Unless we are willing to assume an unusual amount of impaired fecundity among the couples in our sample†, it is only by supposing that contraception is widely practiced that we can account for the small number of children fathered by the graduates. The fact that some of the one-child families had no children at all until 1941 is compelling evidence of the practice of effective contraception among this particular group of men and their wives, at least up to that date‡. The spacing of children among the three children families (Table III) testifies to effective contraceptive practice too.

Economic Insecurity

The period during which the members of our group prepared to marry or were married and the years in which they raised their families, was characterized by severe dislocations throughout all levels of the American economy. Probably, this event interfered with their fertility, and prevented some individuals who otherwise would have had two or three children from achieving this number. The Alumni Records files yielded some information which may be understood to confirm this suspicion.

First of all, the men who have had three children and are employed in business tend to stick with one firm and move up gradually

*There is "a sharp increase of voluntary childlessness with the decrease of economic security."[6]

†In the report of their Indianapolis study, Kiser and Whelpton concluded that 24.6 of the couples in which the husband had one year or more of college suffered from impaired fecundity.[5]

‡"An analysis of the information regarding the 382 couples with no live births [in Indianapolis] indicates that between 32.7 and 47.6 percent were childless because of control measures and between 52.4 and 67.3 percent because of impaired fecundity."[4]

through the ranks, while the men with one child shifted from company to company and from one region of the country to another. It may have happened that the men who shifted were hit more severely by the depression and lost their jobs.

Secondly those graduates who were in occupations in 1950 where tenure is more certain and pay higher have had more children than the individuals who had less favored positions. For example, if we compare the occupations of the fathers who have three children with those of the graduates who have one child, we find that the former are more secure economically. Of the 11 men who had three children, five were professionals: a dentist, two lawyers, a physician and a superintendent of schools; two were owners of medium-sized businesses; and three were in top managerial posts in industry. One of the men who is a father of three children could not be called "successful": he was a professional gambler who moved from region to region. It is significant that he was a deviant in other respects too. He was a drunkard, he was arrested a few times, and finally committed suicide. Also, he was the only man among the graduates to get married while he was still in college, and to have a child before he graduated.

TABLE III. Birth-Spacing in three-child families.

Occupation	Age of Husband at Marriage	Age of Husband at Birth of First Child	Second Child	Third Child
Gambler	22	22	24	28
Sup't of Schools	23	26	31	34
Chicken Farmer	23	33	35	36
Executive	24	26	31	34
Top Manager*	27	30	32	42
Real Estate Agent	28	30	36	40
Attorney	28	37	39	41
Sales Manager	30	31	35	40
Physician	31	33	35	37
Attorney	33	39	41	43
Dentist	37	38	41	44

*In all the cases tabulated except this one, the third child is never separated from the second by more years than twice the number which separates the second from the first child. In the case of the top manager, the number of years separating the second child from the third is five times the amount separating the first and second child. We have reason to believe the third child may have been "unplanned." The top manager wrote as follows to his class secretary when he was thirty-nine years old: "[His wife] and I are trying to keep up with the pep and energy of our two daughters. Needless to say middle age creeping up on us doesn't give us a chance." Three years later when the third child was born, he wrote again to the secretary of his class: "The past twelve months have been extremely busy ones. With young [Name of child] arriving, our household had to do a lot of adjustment, and [His wife] and I had to learn baby care with its special hours all over again. At our age and with a ten year interval, it was quite a task for us."

The graduates who have one child are mostly salesmen and small businessmen: four are salesmen, four are small businessmen, one is a professional and one is a top manager.

Those graduates who are more secure today also probably suffered less from the depression fifteen to twenty years ago. Although we may not choose to interpret those data as an index of the experience of the graduates during the depression, there is no doubt that it confirms the usual inverse relationship between fertility and socio-economic status.

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5. ———— and ————. *Ibid.* 27: 201. 1949.

6. ———— and ————. *Ibid.* 29: 96. 1951.

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(Received October 10, 1951)

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BIOSTATISTICS CONFERENCE

A FIVE-WEEK conference on Biostatistics is to be held at Iowa State College at Ames, Iowa, June 16 to July 23, 1952. It will be conducted as was the highly successful conference on *Heterosis* in 1950. The general theme is the use of quantitative methods in biology. Each day will begin with a lecture by a biologist on a problem which seems amenable to quantitative treatment, and a lecture by a statistician on quantitative methods which seem appropriate for problems of that kind. Discussion sessions will be held later in the day. General themes for the five weeks are tentatively set as: Development of quantitative biology; Specification of populations and their processes; Estimation of population; Individual growth; Biomathematical mechanisms within the individual and species. For details inquire of Professor T. A. Bancroft, Statistics Department, Ames, Iowa.

A PEDIGREE OF BROWN TEETH

The Inheritance of Brown, Enamel-Deficient Teeth in a Utah Family

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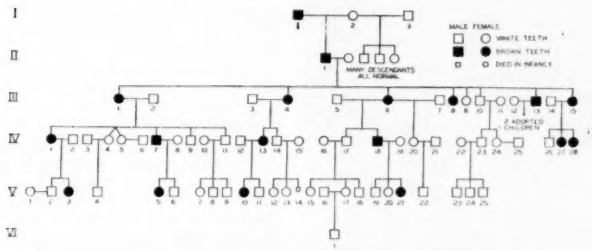


PEDIGREE CHART OF BROWN-TOOTH FAMILY

Figure 3

Black squares and circles symbolize affected males and females, respectively, with brown, enamel-deficient teeth. The defect occurs in both sexes, and is dominant in inheritance.

SOFT, dark colored teeth, deficient in white enamel are known to be inherited in some family groups. An hereditary pattern for this character was decribed by Clark and Clark[1]. These authors characterized the abnormal teeth as brown in color, lacking in enamel and only about one-half to two-thirds normal size. All the teeth, both deciduous and permanent, were affected. A central pulp area was present although sometimes partially filled with dentine and apparently free from nerve connections. A dominant mode of inheritance was indicated. Two pedigrees were presented in which the pattern expected from a single dominant gene was interpreted. The families represented by the two pedigrees were believed to be related somewhere in their ancestry but the relationship was not established.

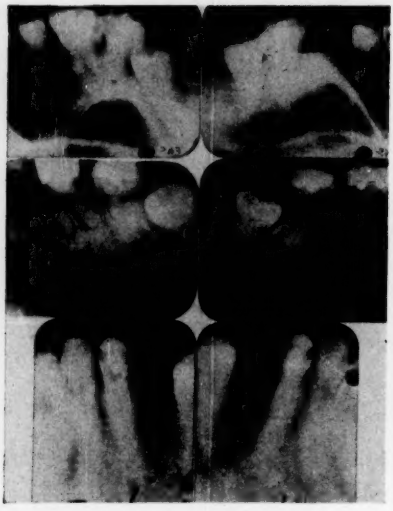
Keeler[2] published seven pedigrees from his studies in which the inheritance of this trait was illustrated. The probands for most of these family groups were patients seen at a large eastern infirmary. Some were obtained from other institutions. Keeler also cited four other pedigrees from the literature including the two by Clark and Clark. A total of eleven pedigrees were thus summarized. The pattern of dominant inheritance was consistent with all the data included in this review.

New Pedigree Presented

The group reported here was brought to the attention of the writer by a student in a genetics class. The pedigree is represented diagrammatically in Figure 3. The Roman numerals at the left indicate generations and the arabic numbers identify individuals. The paternal ancestor (I-1) was born and lived during his early life in Iowa. His wife (I-2) and her three-year old son (II-1) left him and moved to Utah in 1860. Family records indicate clearly that II-1 and his father (I-1) had brown teeth. The father (I-1) is thought to have remarried. It is likely that another branch of the family originating in the vicinity of Iowa may carry the same trait. Most of the people described here and represented in Figure 3 were born in Utah and have lived in the same community all of their lives.

The pattern of inheritance illustrated in Figure 3 is clearly that of a dominant gene. It will be observed that only affected individuals pass the trait on to their children. About half of the children of affected parents express the trait. From the affected parents in generations II, III, IV, and V, 16 affected and 15 non-affected individuals were produced. There are no intermediates in this family group although some family members insist that the brown teeth are becoming slightly lighter in more recent generations. It is possible to distinguish readily between the brown and white teeth.

The teeth are small, soft and brittle and wear readily down to the gums. They do not hold fillings well. Therefore, most of the



BROWN AND NORMAL TEETH
Figure 4

The upper series shows roentgenograms of brown teeth from a female 21 years of age, showing pulp canal filled with dentine. Normal teeth with "open" pulp canals are shown in the lower series. Roentgenograms were made by Dr. L. E. Ottenson.

affected individuals in generations III and IV have had all of their teeth extracted. Most of them live in the same community and one dentist has done most of the dental work for the family. He says there is little hope in trying to fill the teeth. They are also difficult to extract because of their brittleness. Histological studies have not been made but the dentist considers the enamel to be thin and abnormal and not entirely lacking. Some variations in quantity of enamel have been observed which may account for the variation in color. The affected individuals feel no pain from their teeth under any circumstances. Evidently no nerve connections are present. The pulp cavity is completely filled with dentine in all cases which have come to the attention of the dentist. There is evidence, however, of the presence of a pulp canal in early stages of development. X-ray pictures of the remaining teeth of V-3 at 21 years of age are shown in Figure 4 along with pictures of the incisors of V-2 for comparison. It will be observed from the pictures that the pulp canal is completely filled in all teeth of V-3, while the canal is present and readily observed in the teeth of V-2.

Summary

A pedigree of a Utah family group is presented for a trait characterized by brown, soft, enamel-deficient teeth. A total of eighteen affected individuals were identified in five generations. The pattern of simple dominant inheritance was indicated.

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(Received September 19, 1951)

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PLANT BREEDER SEEKS POSITION

One of the associates of the late Nicolai Vavilov is available for employment in plant breeding and selection in the United States. This man was with Vavilov during the last year that he directed plant breeding and genetics in the Soviet Union. He has worked with sugar beets and with legumes and some of the varieties originated by him are at present being used in the Ukraine. In 1943 he was deported by the Germans and the end of the war found him in the U. S. Zone. He came to the United States in 1949.

Inquiries regarding this worker will be forwarded through the office of the Journal of Heredity.

A SHORT METHOD FOR CALCULATING AN F_2 DIHYBRID SEGREGATION

With Linkage

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IN elementary genetics courses, a Punnet Square or checkerboard is typically used for calculating an F_2 dihybrid segregation involving linkage[2,3,4]. Although this method is clear and precise, it is tedious and time-consuming since it involves a minimum of 52 separate steps after the determination of the proportions of the four types of gametes produced by the F_1's. During the past year in his elementary genetics classes, the author has employed a short method that requires only four steps after the determination of the proportion of the double recessive type gamete. This latter method is fully as accurate as the checkerboard method, and it stresses the two basic monohybrid segregations involved in the cross. Furthermore, unlike the short method presented by Mather[1], this latter method does not require the use of two formulae, one for the coupling phase and one for the repulsion phase. With nearly equal ease it may be employed also for a mixed cross involving one parent in the coupling phase and the other parent in the repulsion phase. For practical purposes, the major uses of this method would be in its application to Chi-Square tests and in breeding programs involving genes having known linkage values.

Method

An examination of the F_2 zygotic combinations that occur by random combinations of gametes from an F_1 double heterozygote involving linkage, *e.g. AB/ab or Ab/aB*, shows that (1) the F_2 double dominant class, *A-B-*, is composed of nine gametic combinations, which are of five types, namely, *AB/AB, AB/Ab, AB/aB, AB/ab,* and *Ab/aB*, and which embrace three basically different zygotic frequencies; (2) the F_2 single-dominant-single-recessive class, *A-bb,* is composed of three gametic combinations, which are of two types, *Ab/Ab* and *Ab/ab,* and which embrace two basically different zygotic frequencies; (3) the other F_2 single-dominant-single-recessive class, *aaB-,* likewise is composed of three gametic combinations of two types and two zygotic frequencies; and (4) the F_2 double recessive class, *aabb,* is composed of the single combination *ab/ab* having, of necessity, a single zygotic frequency. Only the frequency of the double recessive class may be calculated directly in one step from gametic frequencies; its frequency will equal the product of the proportion of the double recessive female gametes and that of the double recessive male gametes. In those cases where the crossover frequency is the same in both sexes the proportion of the F_2 double recessive zygotes will be equal to the square of the frequency of the double recessive gametes.

Linkage does not influence the basic *monhybrid* F_2 segregations. Consequently, the double recessive class *aabb* and the single-dominant-single-recessive class *A-bb* together constitute 0.25 of the F_2 zygotes since these two classes make up the recessive group *bb*. Likewise, the double recessive group *aabb* and the single-dominant-single-recessive class *aaB-* together constitute 0.25 of the F_2 zygotes since these two classes make up the recessive group *aa*. Similarly, the single-dominant-single-recessive class *A-bb* and the double dominant class *A-B-* together constitute 0.75 of the F_2 since these two classes make up the group dominant for *A*. Likewise the classes *aaB-* and *A-B-* together constitute 0.75 of the F_2 since these two classes make up the group dominant for *B*.

From the preceding considerations, it is apparent that once the proportion of the double recessive class has been calculated, each single-dominant-single-recessive class may be determined by subtracting the proportion of the double recessives from 0.25. Similarly, the proportion of the double dominant class may be determined by subtracting the calculated proportion of a single-dominant-single-recessive class from 0.75; this latter calculation is equivalent to adding the proportion of the double recessive class to 0.50.

The following example illustrates the use of the short method:

PROBLEM: What would be the proportion of each phenotype expected among the progeny of the cross *AB/ab* × *AB/ab* if 20 percent crossing over occurs between *A* and *B* in both sexes?

The non-crossover gametes will be *(AB)* and *(ab)*, each constituting 0.40 of the total gametes; and the crossover gametes will be *(Ab)* and *(aB)*, each constituting 0.10 of the total gametes. The double recessive, *ab/ab*, can result only from the combination of two *(ab)* gametes; hence, such zygotes will compose 0.4 × 0.4 or 0.16 of the total combinations. The single-dominant-single-recessive class, *A-bb*, will compose 0.25—0.16 or 0.09 of the total combinations since the classes *aabb* and *A-bb* together constitute the expected 0.25 that are homozygous for *bb*. Similarly, the other single-dominant-single-recessive class, *aaB-*, will also compose 0.09 of the total combinations. The double dominant class will compose 0.75—0.09 or 0.66 of the total combinations since the classes *A-B-* and *A-bb* together constitute the expected 0.75 that express the dominant *A*. In summary,

16 percent of the F_2's will be *aabb*,
9 percent of the F_2's will be *aaB-*,
9 percent of the F_2's will be *A-bb*, and
66 percent of the F_2's will be *A-B-*.

This method for calculating an F_2 dihybrid segregation involving linkage may be expressed in a formulary manner as follows:

Let x = the proportion of double recessive gametes, then
x^2 = the proportion of *aabb* F_2 zygotes.
$0.25 - x^2$ = the proportion of *aaB-* F_2 zygotes,
$0.25 - x^2$ = the proportion of *A-bb* F_2 zygotes, and
$0.75 - (0.25 - x^2) = 0.50 + x^2$ = the proportion of *A-B-* F_2 zygotes.

Summary

A short method for calculating an F_2 dihybrid segregation ratio involving linkage is presented. This method requires but four steps subsequent to the determination of the frequency of the double recessive gametes only whereas the typical checkerboard method requires a minimum of 52 steps subsequent to the determination of the frequencies of all gametic types. The short method is as accurate as the checkerboard method.

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COOK EATS BABIES

Verbatim gleanings from a 2,000 word article by I. KUZMINOV: *"Malthusianism Which Serves Imperialism—in response to the book written by Robert Cook: The Population Increase is a Dilemna of the Modern Times." From* Pravda, *October 2, 1951.*

Cook, representative of reactionary biology and enthusiastic successor of Weizmann, Mendel and Morgan, says that "the unlimited increase of population destroys hereditary germplasm of races."

What is the meaning of "the crisis of the study of heredity" claimed by Cook? It is simple. Capitalism can neither live nor earn without having wage slaves. The capitalists make profits by exploiting the working class which is at the same time the origin of all the "apprehensions" of the ruling class. Monopoly capitalists want to have wage slaves who do not answer back and fear the increase of "noisy" men discontented with the system of exploitation. . . .

Cook writes that when the population on the earth grows too much in relation to the foodstuffs, "natural" controls, such as wars, hunger, diseases, death-rate of children, etc., fulfill their functions. The author makes beforehand the favorable argument for the Imperialist plunderers and instigators of a new war who use guns, tanks, planes, poison gas, microbe arms and other weapons of massacre to fight the revolting people and the "inferior" races who do not want to suffer under the yoke of imperialism.

The cannibalistic "natural" control of population increase asserted by Cook can be more rightly called the annihilation of inhabitants. This has already been put into practice, surpassing the domain of theory. In World War II the Hitlerite Occupation massacred "inferior" races in order to secure the "Lebensraum" of the "superior" race. After World War II the American Imperialists are putting into practice the "policy" of Hitlerite decapi-

(Continued on page 300)

NOTES ON LINGUAL GYMNASTICS

Frequency of Tongue Rollers and Pedigrees of Tied Tongues in Japan*

TAKU KOMAI

IN 1946 the writer published in the *Japanese Journal of Genetics* a short paper on two hereditary characters of the human tongue. The one character was concerned with the ability of rolling up the lateral edges of the tongue, and the other was a slight abnormality in the structure of frenulum linguae. This paper was reprinted in the popular journal of genetics, *Iden* in 1947, and seems to have been read with interest by many people. Since then, several amateur geneticists, mostly school teachers, worked on the character mentioned first, and reported their results to the writer. The first part of this paper is a kind of summary of these reports. The second part deals with the hereditary abnormality of frenulum linuguae.

1. The Ability to Roll up the Lateral Edges of the Tongue

Incidence of the Lack of this Ability

As shown below, the incidence of the lack of this ability considerably differs according to age. It is very high among young children, it decreases inversely with age, and reaches a fixed value at about twelve. Since all children in the middle and high schools are about twelve years of age, data obtained from them may be considered as representing the fixed value. In Table I are shown the data obtained in schools in various parts of Japan by different observers. The data are divided into two groups, those presented in the first part obtained by direct observation, and those in the second part secured by the questionnaire method. In direct observation each child was examined by the investigator in regard to his ability to do the trick, while the questionnaire method consisted of giving each child a printed card on which he was to record the presence or absence of this ability in himself and in the members of his family. The writer was able to compare the results obtained by these two methods on the same material. He examined for this ability the students in the high school and college in the town of Sasayama in Hyogo Prefecture, where about a half year before members of the biology study group in that high school had been examined by the questionnaire method. The direct observation gave 26.09 ± 2.00† percent and 17.70 ± 1.66 percent non-rollers respectively for boys and girls, while the questionnaire method had yielded 24.80 ± 1.92 percent and 19.73 ± 2.08 percent for the two sexes. This difference between the results obtained by the two methods is not statistically significant in either sex. There is, however, to be seen in this table, a tendency for the data obtained by the questionnaire method to show somewhat lower frequencies of non-rollers than are obtained by direct observation. When the whole data obtained by both methods are compared with each other, they show differences in the two sexes which are statistically significant. It is not known which datum is nearer the reality. Generally speaking the direct observation seems to surpass in accuracy the questionnaire method, because of the more conscientious attitude of the recorder. At any rate, the former is undoubtedly more suitable than the latter for the purpose of making comparisons between different races as regards the character in question, because all the available data for other peoples were secured apparently by direct observation.

Sexual Difference

In Table I the sexual difference in the frequency of the ability is clearly shown: the male group almost invariably shows a higher incidence of non-rollers than the corresponding female group. This difference is not large enough to be statistically significant in some cases. The overall totals, however, show significant sexual difference in both the direct observation group and the questionnaire group. The same kind of sexual difference has been observed in Americans of European origin by Sturtevant,[4] and by Urbanowski and Wilson[5] and among Chinese by Liu and Hsu.[2]

Are There Racial Differences?

In the Americans of European origin Sturtevant[4] has found the incidence of non-rollers to be 37.1 ± 3.9 percent in males and 32.8 ± 4.1 percent in females. His material apparently includes some children below twelve. Urbanowski and Wilson[5] give 34.38 ± 2.19 percent males and 28.36 ± 1.96 percent females, all of whom are college students. These figures, accordingly, seem to be more suitable

*Contribution No. 7 from the National Institute of Genetics, Misima, Sizuoka-Ken, Japan.

†Standard error.

for comparison with the corresponding figures for Japanese. As shown above, the latter obtained by direct observation are: 29.30 ± 0.80 percent for males and 25.49 ± 0.81 percent for females. The difference found between the two peoples is not statistically significant in either sex, thus:

♂ 34.38 — 29.30 = 5.08 ± 2.31; 5.08 < 2.31 × 3.
♀ 28.36 — 25.49 = 2.87 ± 2.12; 2.87 < 2.12 × 3.

When, however, the data obtained by the questionnaire method are used for Japanese, the racial difference becomes statistically significant:

♂ 34.38 — 26.09 = 8.29 ± 2.82; 8.29 > 2.82 × 3.
♀ 28.36 — 20.68 = 7.68 ± 2.52; 7.68 > 2.52 × 3.

It is likely that if more extensive material were obtained, especially for Americans, some racial difference like that found for blood groups or for taste deficiency would definitely be shown to exist for this character also.

Liu and Hsu[2] examined college students from Middle China in respect to this character. They found that the ability was lacking in 40.88 ± 1.82 percent of the boys and in 30.58 ± 2.60 percent of the girls. These figures, as compared with the corresponding figures given above for Japanese, are higher, and the difference found in boys is statistically significant, thus:

♂ 40.88 — 29.30 = 11.58 ± 1.99; 11.58 > 1.99 × 3.
♀ 30.57 — 25.49 = 5.08 ± 272; 5.08 < 2.72 × 3.

It is desirable that more material regarding this character also be accumulated from among Chinese people.

Difference According to Age

Previous to the writer's paper, Yamaura[7] published a study on this problem carried out on children in several schools of various grades in Tokyo. He found that the relative frequency of the persons who cannot do the trick, shows a considerable age difference. Nearly 50 percent of first-grade children in primary schools cannot roll the tongue. The proportion of non-rollers gradually declines in older children, until the sixth grade when the frequency nearly reaches the fixed value. In Table II are incorporated together the data relating to this problem which were obtained by seven different investigators from primary schools in various parts of Japan. Yamaura's data are also included. It is clearly shown in this table that the incidence reaches nearly 50 percent in boys of the first grade, and decreases gradually to below 30 percent in boys of the sixth grade. In girls the incidence is somewhat lower than in boys of the corresponding age, and it shows a regular decrease inversely with age, exactly as in boys.

There are also some differences among the data presented in the same table accumulated apparently by identical methods though by different investigators, and the difference is fairly large in some cases. It is difficult to judge whether this difference is due to the difference in materials or simply to the sampling error. Only further investigation on more extensive material will settle this question.

Mode of Inheritance of the Character

Sturtevant[4] first suggested that the presence or absence of this ability was determined on a monogenic basis, the gene for the presence being dominant over the gene for the absence. Yamaura[7] and the writer[1] arrived

TABLE I. Relative frequency of individuals of above the age of twelve who lack the ability of rolling up the lateral edges of the tongue mostly among high and middle school children in various districts of Japan.

Male		Female				
No.	Total	No.	Total	Source of Material	Method	Examiner
125	504	72	365	Sasayama High School	Direct	Komai & Yano
(24.80%	100%)	(19.73%	100%)	and Hyogo College	observation	
197	597	175	696	Fukutiyama High School	"	Fujita
(33.00%	100%)	(24.60%	100%)	and Nanryo Middle School		
285	862	153	592	Ooki High School	"	Ito, et al.
(33.06%	100%)	(25.84%	100%)	(Kyoto)		
222	829	182	664	Rakuhoku Middle School	"	Teachers of the
(26.78%	100%)	(27.41%	100%)	(Kyoto)		school
206	741	164	610	Taiho Middle School	"	Okuno
(27.80%	100%)	(26.89%	100%)	(Kyoto)		
126	483	94	531	Sasayama High School	Questionnaire	Biology Study Group
(26.09%	100%)	(17.70%	100%)			
231	866	218	966	Schools in Kyoto	"	Komai
(26.67%	100%)	(22.57%	100%)			
512	1951	403	2295	Schools in Kyoto	"	Yamaura
(26.24%	100%)	(17.56%	100%)			
104	548	145	659	Osaka First Normal	"	Aoki
(23.21%	100%)	(22.00%	100%)	School		
230	806	185	767	Kanse Middle School	"	Tabaru
(28.53%	100%)	(24.15%	100%)	(Kuma-gun, Kumamoto)		
383	1424	330	1430	Soto High School	"	Hibino
(26.89%	100%)	(23.08%	100%)	(Seto, Aiti Pref.)		

Average values:	— Male —	— Female —	——— Sexual difference ———
By direct observation:	29.30 ± 0.80	25.49 ± 0.81	29.30 — 25.49 = 3.81 ± 11.4.
By questionnaire method:	26.09 ± 0.57	20.68 ± 0.50	26.09 — 20.68 = 5.41 ± 0.76.

Difference due to method: Male 29.30 — 26.09 = 3.21 ± 0.98.
Female 25.49 — 20.68 = 4.81 ± 0.95.

TIED TONGUE

Figure 5

The frenulum joining the tongue and the floor of the mouth is extended farther forward than in normal persons. The tongue can be protruded only to the extent shown. The movement of the tongue is somewhat hindered by this abnormality. This causes difficulties in pronouncing the sounds *r* or *l* or in playing on such musical instruments as the harmonica.

independently at the same conclusion, each on a different basis. In Table III are shown the data concerning various combinations between parents and children as regards this ability. In this, only the children above the age of twelve are included, in order to avoid complications due to age difference. The data were derived from children in Kyoto schools of various grades from the middle school up, obtained by the questionnaire method. The incidence of the recessive type, i.e. of the persons who do not have this ability, according to these data, is *22.22* percent, so that the rela-

TABLE II. Relative frequency of individuals who lack the ability of rolling up the lateral edges of the tongue among primary school children in Japan. Here are incorporated the materials from various districts of the country: Tokyo (Yamaura), Kawagoé (Suzuki), Gifu (Yamamoto & Kuno), Seto (Hibino), Kyoto (Komai), Nisinomiya (Komai) and Kumamoto (Tabaru).

	Male			Female			
Age	No.	%	Total	No.	%	Total	
6-7	881	49.24±1.18*	1792	792	43.77±1.17	1809	
7-8	792	42.28±1.14	1873	698	37.27±1.10	1915	
8-9	683	37.86±1.13	1804	610	34.42±1.13	1772	
9-10	534	32.48±1.15	1644	442	27.92±1.13	1583	
10-11	565	32.10±1.11	1760	450	27.49±1.10	1637	
11-12	488	27.63±1.06	1766	346	19.58±0.95	1738	

* Standard error.

TABLE III. Number of children possessing (+) or lacking (−) the ability of rolling up the lateral edges of the tongue borne from parents of various combinations in respect to the ability. The material has been derived mainly from school children of various grades and their families living in Kyoto; the children of the age below twelve are not included.

P/F		+×+		♂+×♀−		♀+×♂−		−×−		Total
+	♂	338	928	66	225	87	243	14	48	1444
	♀	590		159		156		34		
−	♂	54	104	42	91	54	126	39	92	413
	♀	50		49		72		53		
Total	♂	392	1032	108	316	141	369	53	140	1857
	♀	640		208		228		87		

Proportion of recessives in the population: $413/1857 = 22.22\%$

Proportion of recessive gene: $q = \sqrt{0.2222} = 0.47$.

Incidence of recessive children:

from +×+ parental combination: expected $10.28 \pm 0.30\%$
observed 10.08%

from +×− parental combinations: expected $31.97 \pm 0.43\%$
observed 31.68%

tive frequency (q) of the recessive gene among this population is $\sqrt{0.2222} = 0.47$. On the basis of this value of q, the expected incidence of the children who lack this ability has been computed according to the usual formulae:

$$R = \frac{q^2}{(1+q)^2} \pm \frac{0.6745\ (1-q)}{(1+q)^2}\sqrt{\frac{q^2}{N\ (1-q^2)^2}},$$

$$S = \frac{q}{1+q} \pm \frac{0.3373\ (1-q)}{1+q}\sqrt{\frac{1}{N\ (1-q^2)}},$$

where R is the proportion of recessives to be expected in the offspring of random matings of dominants together, and S the proportion of recessives to be expected in the offspring of random matings of dominants with recessives.[3] The value of R expected here is 10.28 $\pm$ 0.30 percent, while the observed value is 10.08 percent. Next, the expected value of S is 31.97 $\pm$ 0.43 percent, the observed value being 31.68 percent. Thus in both cases, the observed value is within the limit of the probable error of the corresponding expected value. It seems accordingly safe to decide that the presence or absence of this ability is determined on a monogenic basis, and the gene for its presence is dominant over the gene for its absence. The penetrance of the dominant gene, however, is incomplete. This is clearly shown in the cases where both parents lack this ability. Only 65.71 percent of the children of such parents are devoid of the ability where all of them are expected to be so.

2. Abnormality in Frenulum Linguae

In some people the frenulum linguae which connects the base of the tongue to the floor of the throat, extends forward nearly to the tip of the tongue. In such tongue-tied individuals the movement of the tongue is hindered more or less, and the degree of this hindrance corresponds with the degree of the forward extension of the frenulum. In most cases the tongue can be protruded only a little beyond the lips at most, and it cannot be curved upwards, so that the person who has such a tongue finds difficulty in pronouncing the sound symbolized by the consonants *r* or *l*.

The writer has been able to collect three pedigrees of this small defect from among Japanese people. In the first family the propositus is an apprentice in the sericulture experiment station in Ayabé near Kyoto. He is twenty years of age, and had not realized this defect until he recently began to learn to play on the harmonica, when he found himself unable to blow the bass sound of the instrument. His mother and two younger brothers are similarly affected. Mr. Ichikawa, geneticist at the same station, kindly supplied the writer with this information.

The second is a physician's family named Okubo living in Tokusima in Sikoku. Dr. Okubo and his two sons of whom the elder is a graduate student in the Medical Department of Tokyo University, have this defect. Dr. Okubo states that the front end of his frenulum is at about 1.5 cm. from the tip of the fully stretched tongue, so that he can protrude his tongue hardly beyond the lips, and he finds some difficulty in pronouncing the *r* or *l* sound. His two daughters do not have this defect. The writer is indebted to Dr. Okubo for this information and for the photograph reproduced here.

In the third family, Mrs. U., wife of a professor of biology at the Kyūshū University, and her father are affected, while her mother and brother are both normal. This material has been provided to the writer by her husband Dr. U.

These pedigrees show that this slight abnormality is due to a simple dominant gene. Weiss[6] reports a family of an "adherent tongue." "The patient could not elevate the tongue to make contact with the palate, particularly in the posterior portion, as occurs in producing the sounds of *k*, *q*, hard *c* and hard *g*. The patient could protrude his tongue quite freely, but in trying to elevate it, it seems to be drawn into the throat and would elevate only slightly." This abnormality appeared in a man and his four sons, and probably in the man's brother too, the four daughters all being normal. This case is similar to, though apparently not identical with, the cases here reported. Probably both belong to the category called 'ankyloglossia.'

Summary

1. The incidence of the lack of the ability of rolling up the lateral edges of the tongue among Japanese people is about 29 percent in males and 25.5 percent in females. The incidence thus shows a distinct sexual difference. It also shows a considerable difference according to age. The incidence is higher in small children, approaching 50 percent in seven-year old boys, and decreases inversely with age until it reaches the fixed value at about twelve. The girls always have lower incidence values than boys of corresponding age. It is also likely that the incidence shows some difference in different human races.

2. The presence or absence of this ability is determined on a monogenic basis; its presence is due to a dominant gene, but its penetrance is incomplete.

3. Some people have their frenulum linguae more forwardly extended than in normal persons. This gives some hindrance to the free movement of the tongue, which is manifested in the pronunciation of some sounds or in playing on a blowing musical instrument. This defect is caused by a simple dominant gene. Three pedigrees showing this character are presented.

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◆

GENETICS OF THE COLOR VARIETIES OF HORSES

A Spanish geneticist and agricultural expert has recently published an excellent exposition of color variation among horses and the genetic constitution of the various color varieties.*

Based on twentieth-century genetic theory, it is the most comprehensive work on this subject which has yet been published. It is an example of beautiful book making, with reproductions in color of famous paintings of horses, and numerous other illustrations. The work is well indexed and includes a very complete bibliography, which alone would make it indispensable as a tool of research to future students of the genetics of the horse.

The work is divided into four parts. Part one deals with the basic color varieties; black, brown, bay, chestnut and gray. These are discussed in much detail as regards their occurrence, morphological character, and biochemical basis.

Part two deals in a similar way with "other colors"; a chapter each being devoted to roan, pinto, buckskin-and-Palomino, and white.

Part three deals with the "modes of interpretation" of physiological processes involved in color production.

Part four deals with "genetic interpretations." This is of especial interest to geneticists. Its ten chapters have such suggestive headings as mosaic pelages, dilution, silvering, horses and rodents, horses and hypotheses, attributes of the wild color type.

The author postulates the occurrence among horses of seven different basic genes, each having two or more alleles, and associated in several combinations with a number of hypothetical modifiers. The genes in question are:

1. A^{L}, A, a^{t}, a = wild pattern, bay, brown, black
2. C, c^{cr} = full color, dilute color
3. E, e = extended black color, restricted black color (red)
4. G, g = gray, not gray
5. R, r = roan, not roan
6. S, s = self, minor white spotting
7. W, W' W'' = all-white, white areas extensive, white areas less extensive

The author recognizes the existence of a wild coat pattern seen in the Prejvalski horse, still wild in Mongolia, and regards it as analagous with the agouti pattern of rodents, designating it by the same symbol, A. He suggests that it has undergone mutations resulting in four recognizable alleles; one, the wild type, a second found in bay and chestnut horses (most like the wild pattern), a third found in brown (bocifuego) horses (less like A and regarded as comparable to a^{t}—the black-and-tan pattren of rabbits), a fourth found in black horses shows total absence of the A pattern.

In the reviewer's opinion the assumption of a special mutation of A to produce a phenotype popularly called brown is needless, as browns are demonstrably some modified bays (AB), others modified chestnuts (Abb) and none are true breeding for a brown phenotype.

Combinations of genes recognized by the author as resulting in the basic color types of horses are shown in Tables I and II columns 1 and 2. This layout differs from that of most mammalian geneticists in two particulars.

(1) Odriozola regards all eumelanin of horses as black, and explains the difference between bay and chestnut as due to a quantitative difference in black pigment. Others regard the difference as qualitative, the eumelanin in one case being black, in the other brown. This difference is expressed by Odriozola in terms of genes, by alleles E, e. By others the difference is expressed in terms of the alleles B, b.

(2) Odriozola regards dilution as due to a genuine albino allele, c^{cr} (cream). Heterozygotes with the allele for full color, C c^{cr} are intermediate in depth of color, as seen in buckskin and Palomino varieties, while homozygotes c^{cr} c^{cr} are really a type of albino, as

**A los Colores del Caballo.* [On the colors of the horse, a guide to their varieties and an inquiry into the mode of their origin]. By Miguel Odriozola. 435 pp, 8 colored plates and numerous other illustrations. Publication of the National Syndicate of Livestock, Madrid, 1951.

popularly designated. An alternative view put forward by Salisbury and adopted by the reviewer ascribes dilution to the action of a gene *D* independent of the color gene *C*, incompletely dominant in single dose, and much more effective in double dose, *DD*.

The practical consequences of Odriozola's layout in the two foregoing cases are the same as would result from the alternative layouts mentioned, but they are open to certain objections.

A qualitative rather than a quantitative difference between black and brown eumelanin has long been recognized in rabbits, guinea-pigs, rats, mice, and dogs. The difference between bay and black varieties of horses on one hand and chestnut and liver varieties on the other is a parallel case. But we should *not* employ an *E, e* pair of alleles to explain it, because we have a use for that pair of alleles in explaining extension vs. restriction of black or brown pigment, exactly as in rodents and dogs. So use of the *B, b* pair of alleles seems preferable.

If we assume dilution to depend upon an albino allele, we encounter this difficulty. An albino allele, such as c^H or c^{ch} in rabbits, causes yellow pigment to be weakened or to disappear while black pigment is less affected, but in horses just the reverse difference in dilution is noticed. Black is affected more than yellow, which remains as the most conspicuous element in the body color of buckskin and Palomino horses.

It is known that in rabbits, guinea-pigs, and dogs both the *B, b* gene pair and the *E, e* pair are present, and that they act in different ways to restrict the development of black pigment in the coat. The mutation from *B* to *b* causes a qualitative change in the pigmentation from black to brown. The mutation from *E* to *e* causes a restriction of black or brown pigment for the most part to the eyes and skin, leaving a yellow-red pigment predominant in the coat.

Odriozola assumes that among horses only the *E, e*, mutation has occurred, and he assigns to this the same function as others assigned to the *B, b*, mutation.

The reviewer, in certain previous publications, has made no mention of the *E, e* mutation in explaining the basic color classes of horses, because it seemed to make the matter needlessly complicated for the comprehension of horse breeders unschooled in genetics. For the ancestral wild coat pattern of horses (bay) is itself a restriction of black dependent upon gene *A*. If this mutates to the recessive allele, *a*, the pattern disappears and a uniform black results. Its genotype then is *aaB*. If then, the *B, b* mutation is added, we acquire four basic color types, as shown in Table I, middle column.

If we assume that among horses, as among many other mammals including rodents and dogs, both the *E, e*, and the *B, b*, mutations are present, a much fuller explanation can be made of color variation in horses. See Tables I and II, last column. Among other things, the occurrence of a dominant black mutation among horses, would be understandable.

Odriozola does not recognize the existence of a dominant black variety of horse, which has been assumed by the reviewer in earlier publications to explain the occasional production of bay colts by black parents. In other mammals in which dominant black varieties have been clearly shown to occur, they arise demonstrably through mutation in gene *E* to E^D. This may well also be true in horses, an additional reason why gene *E* should be included in a genetic scheme for horses.

The genetic constitution of a dominant black horse would then be ABE^D, that of a recessive black *aaBE*, as is the case in rabbits.

The distinction between gray and roan, a matter long obscure, has been clarified by

TABLE I. Contrasted Genetic Schemes Involving a Single Gene Restricting Distribution of Black Pigment, or Two Diffrent Restricting Genes.

	E, e only Odriozola	*A, a* only Castle, 1948	Both *A, a* and *E, e*	
Bay	*A E*	*A B*	ABE	Ordinary bay
			ABe	Light bay
Black	*aaE*	*aaB*	aaBE	Ordinary black
			aaBee	Smoky black
Chestnut	*Aee*	*Abb*	AbbE	Ordinary chestnut, brown mane
			Abbee	Sorrel, light mane
Liver chestnut	*aaee*	*aabb*	aabbE	Coat uniform brown
			aabbee	Coat uniform red

TABLE II. Contrasted Genetic Schemes Involving Dilution.

	Genes *AEC* Odriozola	Genes *ABD* Castle, 1950	Genes *ABDE*	
Dun or buckskin	*A-E-C-c^{cr}*	*A- B-D-*	*A-B-D-E—*	"Blue dun," sooty yellow body, black mane, tail, legs.
			A-B-D-ee	Buckskin, "yellow dun," clear yellow body, black mane.
Palomino	*A-eeC-c^{cr}*	*A-bbD-*	*A-bbD-ee*	Palomino, sooty yellow body, light mane.
			A-bbD-ee	Palomino, clear yellow body, white mane.
"Albino" type B	*A-E-$c^{cr}c^{cr}$*	*A-B-DD*	*A-B-DDE—*	Type B, body sooty cream, dark mane.
			A-B-DDee	Type B, body clear cream, mane less dark
"Albino" type A	*Aee$c^{cr}c^{cr}$*	*A-bbDD*	*A-bbDDE—*	Type A, pink skin, blue eyes, body very pale cream, somewhat sooty.
			A-bbDDee	Type A, skin and eyes as above, body very pale cream, not sooty.

the author. Both mutations involve silvering, a mixture of white with colored hairs in the coat.

The author maintains that the essential difference between gray and roan consists primarily in a difference in the time of first appearance of silvering in the coat and in its progressive or non-progessive character; secondarily in a difference in the distribution of the silvering which in a roan is confined largely to the trunk, the extremities being little affected.

In the Percheron breed, basically black in color, the colts are born black but post-juvenile coats develop silvering which becomes progressively greater until in old animals the coat may be practically all white, a condition which is never attained in roan horses.

Both gray and roan mutations may be present in all basic types of colored coat such as black, bay and chestnut.

Crosses of gray with roan are reported to have produced gray, roan and non-silvered offspring, a result to be expected if both parents were heterozygous, *Gg* and *Rr* respectively.

The genetic scheme of the author would make dominant white (*W*) an all white mutation (probably lethal when homozygous like the similar mutation in mice). The designation *W′ W″* for genes effective in producing types of pinto (pied) with more or less extended areas of white, would seem to imply that these are regarded as alleles of dominant white. But it is doubtful if this is the author's real intention. It is probable that several independent mutations affecting white spotting exist in horses as they demonstrably do in rabbits, mice and dogs.

A colored plate at the conclusion of the text shows two color novelties which the author regards as future possibilities, a uniform blue and a uniform brown horse. He bases the expectation on the existence of blue and brown mutations in other mammals, rodents, and dogs. For the reviewer one of these anticipations is already realized in the liver chestnut, a uniform brown type; the other, uniform blue, it must be admitted is not as yet known to have materialized.

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✦

APPROACH TO GENOTYPIC EQUILIBRIUM WITH VARYING PERCENTAGES OF SELF-FERTILIZATION AND CROSS-FERTILIZATION (ONE AUTOSOMAL GENE-PAIR)

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COMPLETE self-fertilization yields homozygosity fairly rapidly. The progression shown by Mendel[2] for one pair of (autosomal) genes indicates that one-half of the residual heterozygosity is lost in each succeeding filial (F) generation. Equilibrium is approached as the number of filial generations increases without limit. The limiting values for the genotypic frequencies are: $qAA:(1\text{-}q)aa$, where q is the decimal frequency of the "*A*" gene, and $(1\text{-}q)$ is the decimal frequency of the "*a*" gene.

Complete cross-fertilization, on the other hand, yields equilibrium in one generation of random mating, assuming P_1 genotypic frequencies to be the same in both sexes. The point of equilibrium is $q^2AA:2q(1\text{-}q)Aa:(1\text{-}q)^2aa$.[1,3]

In both the above cases it is assumed that there are no causes of variation other than the segregation of the one autosomal pair involved. All genotypes are equally viable and fertile; and there is no overlapping of generations.

Among plants, in particular, there are species with some proportion of self- and cross-fertilization, as well as forms which approach 100 percent self- or 100 percent cross-fertilization. It is of interest, then, to set up a formula which would yield genotypic frequencies at generation F_n and $F\infty$ with various proportions of cross- and self-fertilization, and various gene frequencies.

The symbols which will be used are:

q = decimal frequency of allele *A*
$(1\text{-}q)$ = decimal frequency of allele *a*
r = decimal frequency of self-fertilization
$(1\text{-}r)$ = decimal frequency of cross-fertilization
F_n = number of filial generations following P_1

Beginning with a P_1 of $q^2AA:2q(1\text{-}q)Aa:(1\text{-}q)^2aa$, it follows that $(1\text{-}r)$ of the P_1 will remain in equilibrium in the F_1; and r of the P_1 will lose one-quarter of its heterozygosity to each homozygous genotype. The two are averaged for the final F_1.

At F_n the formula resolves to:

$$\left[q^2+q(1-q)\left(\frac{\left(\frac{r}{2}\right)^{n+1}-\frac{r}{2}}{\frac{r}{2}-1}\right)\right]AA:\left[q(1-q)\left\{2-\left(\frac{r\left(\frac{r}{2}\right)^n-r}{\frac{r}{2}-1}\right)\right\}\right]Aa:\left[(1-q)^2+q(1-q)\left(\frac{\left(\frac{r}{2}\right)^{n+1}-\frac{r}{2}}{\frac{r}{2}-1}\right)\right]aa$$

The limiting genotypic frequency ($F\infty$) would be:

$$\left[q^2+q(1-q)\left(\frac{r}{2-r}\right)\right]AA:\left[q(1-q)\left(2-\frac{2r}{2-r}\right)\right]Aa:\left[(1-q)^2+q(1-q)\left(\frac{r}{2-r}\right)\right]aa$$

It frequently happens that the P_1 is not in the ratio: $q^2AA:2q(1-q)Aa:(1-q)^2aa$. Using the symbol "2*i*" for the decimal proportion which the heterozygote would have to lose (positive "i") or gain (negative "i"), at F_n the ratio would be:

$$\left[q^2+q(1-q)\left(\frac{\left(\frac{r}{2}\right)^{n+1}-\frac{r}{2}}{\frac{r}{2}-1}\right)+i\left(\frac{r}{2}\right)^n\right]AA:\left[q(1-q)\left\{2-\left(\frac{r\left(\frac{r}{2}\right)^n-r}{\frac{r}{2}-1}\right)\right\}-2i\left(\frac{r}{2}\right)^n\right]Aa:\left[(1-q)^2+q(1-q)\left(\frac{\left(\frac{r}{2}\right)^{n+1}-\frac{r}{2}}{\frac{r}{2}-1}\right)+i\left(\frac{r}{2}\right)^n\right]aa$$

The term $i(r/2)^n$ approaches zero as n increases without limit. Therefore, the limiting ratio ($F\infty$) would be the same as if the P_1 had been in the proportions: $q^2AA:2q(1-q)Aa:(1-q)^2aa$.

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COOK EATS BABIES

(Continued from page 292)

tators by murdering peaceful Koreans. . . .

Each number of "The Hereditary Magazine," organ of the Association of the scientists belonging to the school of Morgan in the United States, propagates Malthusianism and racism.

At present the problems of "population increase," "overpopulation" and "eugenics" are the center of attention of the governments of the United States and Great Britain. Cook published the theory attributing the hard life and poverty in Puerto Rico to overpopulation. This was borrowed from a report of the American Customs Committee which had investigated the situation in Puerto Rico in 1945. Sterilization is enthusiastically recommended to the woman waiting their impending marriages in Puerto Rico and concrete measures have already been taken for this purpose. . . .

Committees dealing with the question of "overpopulation" in all governments are now showing positive activities not only in colonies but also in sovereign countries. The report of the Population Problems Committee of the National Security Resources Board of the United States is based on Cook's theory of murder. The fantastic sterilization laws for "inferior" races and of the "insane" are adopted in many states of the United States. These laws are utilized as a weapon of fight against the progressive elements of the people (as was the case in the former Hitler Germany).

In Great Britain a Royal Committee for the question of population is established. Cook seems quite satisfied when he points out that the conclusions of the committee are completely the same as his.

Our foregoing inquiry shows that Cook's doctrine is neither a simple idea of a crazy racist nor a naive playing with theory. Behind him are prominent figures of Wall Street and the City, and Anglo-American imperialistic looters.

Corrupt capitalism and its ideology emit a nauseating smell. The people of the world must know what imperialistic burglars are plotting, and fight more severely in defense of life, peace, and socialism.

To get a struggling Mendel-Morganist, the National Resources Board of the U. S., The Royal Population Commission of Great Britain, Adolph Hitler and the "invasion" of North Korea into one tent should qualify Comrade Kuzminov for a Stalin Award in Journalism, first class.—R.C.

THE GENETIC THEORIES OF EMPEDOCLES

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BY some time in the fifth or fourth century B.C. (depending on how long the theory antedated the report of it in the psuedo-Hippocratic *On Diet*), Greek medical men in the eastern Mediterranean had developed a genetic combination-theory to explain how the sexual potencies carried by the "seeds" of male and female parents combined to determine the sexes of their children.[1] The most unsatisfactory aspect of this theory as a basis for anything approaching a scientific genetics was the fact of its *intransitivity*. The sex inherited by a parent was assumed to have no effect on the range of potencies which that parent's "seeds" would carry, hence if this combination technique were generalized to include other inherited traits, the heredity of a first generation would not be thought of as establishing any limitations on probabilities for the inherited traits of a second generation. While this approach might seem satisfactory so long as attention was confined to sex inheritance, it clearly will not explain how other traits are transmitted, such as eye-color and stature. These observations would show that the heredity of the parents does in fact set limitations and probabilities as to what the heredity of their children will be.

At this same time, and even earlier, the Greek medical school at Crotona, in the west, seems also to have been speculating about the mechanism of heredity. At some time close to 440 B.C., a combination theory of heredity, in which there was provision for the continuity of transmission of traits through successive generations was developed by the philosopher and scientist Empedocles, a native of Akragas, to explain the phenomena of "family resemblance" in physique and features.

Empedocles is a man who has never received just appreciation from posterity, because of his habit of merging fields and ideas which posterity has felt should be assiduously separated. Thus his synthesis of chemistry and metaphysics has not appealed to philosophers. His fusion of public health medicine with rites of religious purification has not seemed reasonable to doctors. His lyric poems on natural selection and the biological sciences have jarred the sensibilities of most later biologists and lyric poets alike.[2] On the other hand, Empedocles' experimental proof of the corporeality of air [detached from the speculative inferences he drew from the experiment] has often been cited as a landmark in the history of experimental science.

At any rate, the account that emerges from the reports and fragmentary direct quotations that we possess, is that of a keen and interested observer, eager to combine the insights of different specialists by what frequently seems to us an unwarranted excess of speculative imagination. If, in addition to being curious and speculatively imaginative, Empedocles was also vain, pompous, and superstitious, these traits are partly justified by his own contemporary importance in Sicily. They were partly inevitable in a product of the Western Greek cultural environment, and in any case do not seem to have intruded themselves in his scientific observations and speculations. This picture of the character of Empedocles is important for an understanding of the reconstruction of his theory which follows.

Censorinus' Account

Our account of the Empedoclean theory of family resemblance comes from Censorinus, writing much later.[3] Censorinus preserves a list of combinations (of the relative heat of the seeds contributed by each parent) which, he says, Empedocles used in the family-resemblance theory. But the interpretation attached to this list certainly is not the one that Empedocles intended.

In the first place, Censorinus represents the combinations as explaining the inheritance of

sex in the manner of the Hippocratic combination diagram. Actually we know, from the much more reliable report of Aristotle, that Empedocles had said sex-determination depended only on the temperature of the embryo's intrauterine location. Hence this was not an hereditary explanation of sex at all, rather an *environmental* explanation.[4] That Empedocles probably did hold such an environmentalist view is confirmed by the contemporaneous development of other environmental theories of sex-determination in the western Greek world.[5]

In the second place, Censorinus' interpretation takes no account of the *degree* to which family resemblance is inherited. It is quite incredible that some explanation of this easily observable variation was not given in Empedocles' original theory. Particularly is this so since this fact of variation in degree was the empirical evidence cited in defense of the theory of the medical school at Crotona.[6] Presumably at some point the influence of the eastern medical school led to a recasting of Empedocles' diagram, so that a list of sexes and resemblances, by assimilation with later current notions of sex-determination, was reinterpreted as a list of sexes of offspring and their resemblance to parents.

Philologically, such a reinterpretation would have been easy. Psychologically, at the hands of a scientist in whose mind combination patterns were firmly associated with sexual inheritance, this revision is easily understandable.

The matrix in Censorinus' version is:

		seed of female parent	
		HOT(H)	COLD(C)
seed of male parent	HOT	*HH*	*HC*
	COLD	*CH*	*CC*

HH—male child resembling male parent
HC—male child resembling female parent
CH—female child resembling male parent
CC—female child resembling female parent

More probably, the original interpretation ran:
HH—slightly resembling male parent [more than female line]
HC—strongly resembling male parent
CH—strongly resembling female parent
CC—slightly resembling female parent

In this reconstruction, the same matrix is used that the tradition had preserved; but the notion of hereditary determination of sex is not forced on Empedocles; and the relative potency of the two seeds is made the determinant of the nature and degree of inherited family resemblance. If this list were originally written in any abbreviated form, it could easily be read to make the sexes referred to alternately those of parent and child, instead of parent throughout.[7] Further, whatever terms were used for "weak" and "strong" could have seemed to such a paraphraser chemical characterizations, genetically irrelevant.

Since the sex of the child was determined, on Empedocles' theory, by its embryonic environment — "Hot" or "Cold," independent of any inherited appearance, the combinations as he saw them must have been:

		Embryonic Environment	
		Hot	Cold
HEREDITY*	*HH*	*M-r-M*	*F-r-M*
	HC	*M-R-M*	*F-R-M*
	CH	*M-R-F*	*F-R-F*
	CC	*M-r-F*	*F-r-F*

*heat of seed from each parent; male given first.

The first symbol, *M* or *F*, indicates the sex of the child, the third symbol the sex of the parent whose family line the child most resembles, and *r* and *R* whether there is a weak (*r*) or strong (*R*) degree of resemblance.

This theory combined for the first time several genetic insights, which, with a different subsequent history of medicine and philosophy, could have been of decisive importance. These are as follows:

1. Inherited traits are discrete and exclusive. On this point Empedocles' own philosophical theory of elements seems to have led him to diverge from the locally current opinion of his time that the traits inherited were an average of those possessed by the two parents. Instead, heredity of traits is here formulated as an alternative relation; either the child inherits resemblance to one parental family-line or to the other.

Both family lines determine the possible heredity of a child. This view is adapted from the current theories; it certainly contradicts the superstition some modern geneticists promulgate and hold, that the early Greeks thought traits were inherited from the male parent alone. This was the doctrine of only a few Greeks, and of none of the really early ones.

2. For the first time, a combination list is interpreted as transitive, that is, the heredity of the first generation limits the possible traits which that generation can transmit to the second, and so on through a family tree. Thus the child of a father who resembled his own father's family may inherit a resemblance to his paternal grandfather, but cannot inherit resemblance to his paternal grandmother's line.

Thus at its very outset, thanks to the talent of an early Greek philosopher, speculation regarding genetic phenomena was much closer to our contemporary notions than geneticists unaware of this early history of their subject could suppose.

Unfortunately, the western Greek medical tradition, while retaining the notion that heredity is transitive, did not adopt the doctrine that traits are discrete and inherited on an

either-or basis. In the eastern medical tradition, this discreteness of hereditary traits was recognized, but in a form which eliminated their transitivity. In their philosophic doctrines, where considerations of genetic theory appear that had a decisive historical importance, Plato seems to have followed the western medical tradition, and Aristotle a modified version of the eastern tradition.

Sources and Notes

1. pseudo-Hippocrates, *On Diet*, ii.23; R. G. Bury, *The Symposium of Plato*, xxxii-xxxiii.

2. An exception to the general reaction of poets is W. E. Leonard, whose metrical translation of *The Fragments of Empedocles* is poetic and sympathetic. The fragments are given in Greek in Leonard's translation; also, in German and Greek, in H. Diels, *Fragmente der Vorsokratiker*, 3rd edition, I, 193-283, and in English prose in Kathleen Fuller, *The Pre-Socratic Philosophers*. A coin issue of the city of Selinus commemorating a public-health project directed by Empedocles is described in B. V. Head, *Historia Numorum*, p. 168.

3. Censorinus, *De Die Natali*, [238 A.D.], 5,4; quoted in Diels, *op. cit.*, I, 215-16: ex dextris partibus profuso semine mares gigni, at e laevis feminas Anaxagoras Empedoclesque consentiunt. quorum opiniones, ut de haec specie congruae, ita de similitudine liberorum dispariles; super qua re Empedoclis, disputata rationes, talis profertur. si par calor in parentum seminibus fuit, patri similem marem procreari; si frigus, feminam matri similem. quodsi patris calidius erit et frigidius matris, puerum fore qui matris vultus repraesentet; at si calidius matris, patris autem fuerit frigidius, puellam futuram quae patris reddat similitudinem.

4. Aristotle, *De Generatione Animalium*, 746a 1; Diels, *op. cit.*, 215-16.

5. Cf. Parmenides, [fl. 475 B.C.] fragment 17, Diels, *op. cit.* I, 163; Burnet, *Early Greek Philosophy*, 5th ed., p. 178.

6. This Pythagorean-Crotonian position is echoed by Plato, and one of its genetic diagrams preserved by Plutarch, *De Iside et Osiride* 56, p. 373F; translated and discussed by Sir Thomas Heath in *The Thirteen Books of Euclid's Elements*, 2nd edition, pp. 417-18.

7. Note that the compression of Censorinus' statement may quite possibly echo the terseness of his original.

◆

DAIRY COW HAS PARTURITIONS THREE WEEKS APART*

EVEN though the dairy cow usually produces only one offspring at a birth, twins are moderately frequent. Pfau *et al.*[3] reported 3.95 percent twinning in a Holstein herd over a period of fifteen years. Lush,[2] in a study of the hereditary aspect of twinning, reported as high as 8.8 percent twinning in individual herds.

Several studies have found that twin gestations are generally of shorter duration than the gestations of single births.[1,3] It has also been reported that the condition of retained placentae was very much aggravated by the occurrence of twinning.[3] However, it is rather unusual for normal twins to be born more than a few days apart.

A case of a grade Holstein cow that reportedly gave birth to two normal calves 23 days apart was investigated by the writers. This cow, eartag number L228197, owned by the District Training School, Laurel, Maryland was bred artifically to the Holstein bull, S. J. C. Valley Emperor Star 857269, by a technician of the Maryland Artificial Breeding Cooperative on August 6, 1947. Twenty-two days later on August 28, 1947, the Herdsman observed this cow again showing external signs of estrus and reported her to the technician for a second service. Semen from the same Holstein bull was available for this second breeding, as collections are generally made once each week from the bulls in the stud.

On May 14, 1948, cow number L228197 dropped a normal heifer calf. As this calving followed the service of August 6, 1947, by a gestation period of 282 days, the Herdsman assumed that the cow had conceived from this service and that the signs of estrus observed at the time of the second breeding were due to a "false heat." The passing of a placenta was observed, and on the seventh day following parturition milk production was up to 48 pounds per day.

However, on June 6, 1948, the Herdsman reported that cow number L228197 had dropped a second normal heifer calf, and that another placenta had then passed. This second parturition followed the second service by 282 days and the first service by 305 days.

Blood Types

Blood types of the four animals concerned were made by Dr. Clyde Stormont, Depart-

* Miscellaneous Publication No. 73, Contribution No. 2118 of the Maryland Agricultural Experiment Station (Department of Dairy Husbandry), College Park, Maryland.

"HALF TWINS" WITH DIFFERENT BIRTHDAYS

Figure 6

With a two-week interval between births, these calves represent a very unusual variation of the twinning process.

ment of Genetics, University of Wisconsin.* The blood types were found to be as follows:

Sire: S. J. C. Valley Emperor Star	Q	O_2	Y_1	E'_1	C_2	W	L	F	A	H′	J	Z
Dam: Cow #L228197	G	Y_1	D′	E'_3	C_2	W		F	A	H′		Z
Calf A (dropped May 14, 1948)		O_3	Y_1	E'_3	C_2	W	L	F	A	H′	J	
Calf B (dropped June 6, 1948)	G		Y_1	E'_3	C_2		L	F	A	H′	J	Z

A comparison of the blood-type formulas of calves A and B reveals that these calves differ in blood characters G, O_3, W, and Z. Obviously they could not be identical twins, and apparently they do not have mixtures of one another's blood. Blood mixture is known to occur in a high proportion of non-identical twins, and leads to identity of blood types in most instances.

Discussion

It is difficult to explain many variances from the normal in the reproductive behaviour of dairy cattle on the basis of currently known facts. The available information indicates that cow number L228197 dropped two normal calves 23 days apart as reported. The most feasible explanation seems to be that this was a case of "delayed" twinning, and that the correlation between the breeding dates and subsequent calving dates was accidental. However, since the same sire was used for both services it is not possible to definitely refute the possibility that this cow ovulated at the time of the second service and carried a fetus in each uterine horn for a normal gestation period.

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*The authors wish to express their appreciation to Dr. Clyde Stormont for making the blood types.

THE HOOK-TAILED MOUSE

A Mutation in the House Mouse Affecting the Tail and the Anus

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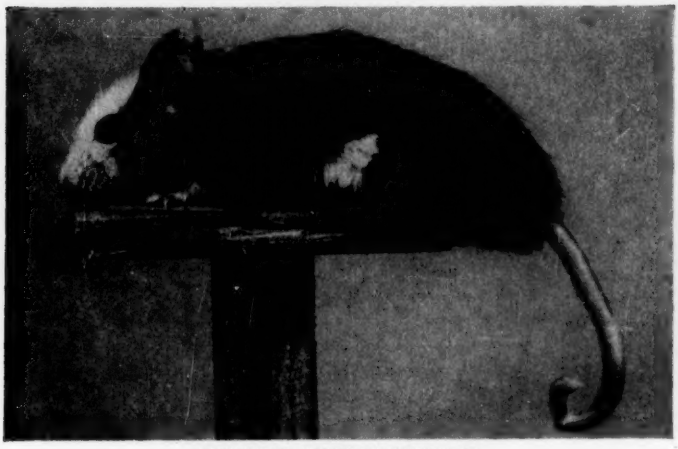


ORIGINAL "HOOK" MUTANT

Figure 7

This offspring of normal tailed parents transmitted fishhook tails to part of his progeny. Abnormality of the excretory system is also characteristic of this dominant mutation.

IN 1949 one male (Figure 7) from a stock mating of normal-tailed piebald shakers was observed to have a shortened tail shaped like a fishhook. When mated to a normal-tailed litter mate, this male sired a female with a hooked tail, and from this arose a stock which is thought to contain a new dominant mutation, Hook (*Hk*).

In the course of classifying litters in this stock, it was noticed that in many Hook animals, the anus was posterior to its normal site, often on the tail, and that sometimes there was a streak or depression on the lower side of the tail extending to as much as half the length of the tail. This displaced position of the anus, which was called High Vent, appears to be an additional and perhaps a primary and constant effect of the mutation responsible for the hook tail.

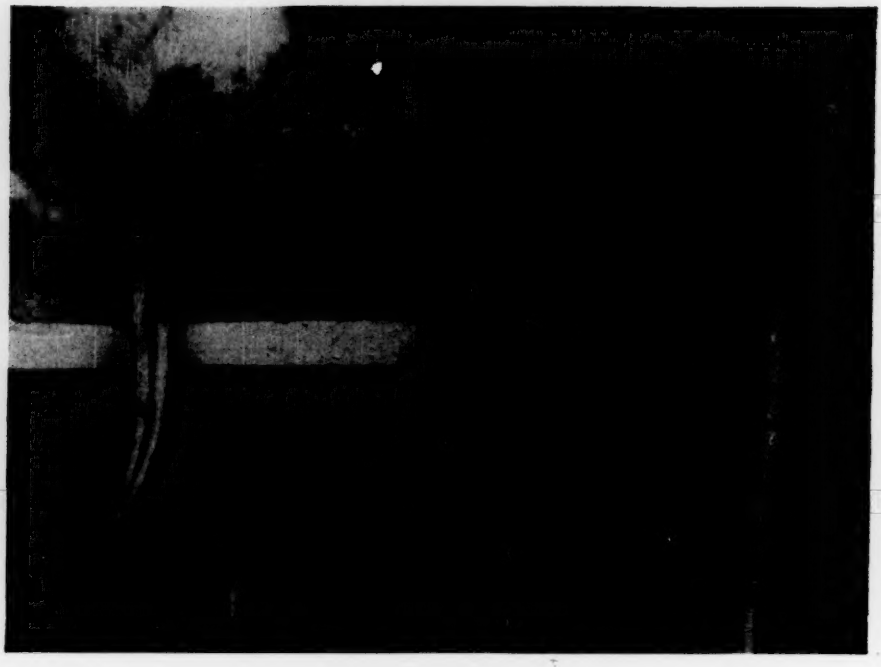
The displaced anus tends to be slit-shaped rather than circular, and to be bare rather than surrounded by hairs as in the normal. In position the displaced anus may be found over a range from slightly posterior to its normal site to an extreme of about 10mm posterior to normal (Figure 8).

Preliminary Breeding Observations

In general, pen matings rather than single pair matings were used, and offspring born in the mating pen were classified at weaning time.

Most of the mice recorded as mutants in the following F_2 and test cross matings were classified according to the position of the anal opening. The length and degree of bending of the tail in animals with high vent is quite variable; but all animals classified as high vent and tested by mating have had Hook

*Manuscript prepared at Nevis Biological Station of Columbia University, Irvington, N. Y., with the advice of Prof. L. C. Dunn and Mr. W. C. Morgan, Jr.



MISPLACED ANUS

Figure 8

Two hooked mutants are shown at left; a normal mouse at right. The "high vent" deviation was highly variable in expression.

and high vent offspring. Some mice with high vent have not shown any gross abnormality of tail although they transmit the mutant condition. This leads to the presumption that the effect on the anus is the more constant feature of the mutation.

Observations to date are as follows:

12 pen matings Hook (or high vent) × normal gave 185 Hook (or high vent) and 184 normal.

21 pen matings Hook (or H. V.) × Hook (or H. V.) gave 318 Hook or H. V. and 202 normal.

5 pen matings of normal × normal from Hook parents gave 102 normal and no abnormal offspring.

Two generations of Hook × Hook matings, from Hook parents, have given 61 mutant offspring and no normals.

These results are consistent with the assumption that *Hk* is dominant and the last result suggests that some Hooks were homozygous, hence that Hook, unlike many dominant mutants, is viable when homozygous.

These assumptions are now being tested in new experiments (Sarasota). Comparison of Hook with some other tail mutations and tests for linkage of Hook are also being undertaken (at the Nevis Laboratory).

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SUPERNUMERARY MAMMAE IN GUINEA PIGS

BETTY LANNING GOERTZEN AND HEMAN L. IBSEN*

THE number of pairs of mammae varies greatly among different species of mammals. Within each species a rather uniform number normally occurs. Those animals which possess several pairs of mammae usually have larger litters than those with a single pair. Guinea pigs, with only one inguinal pair of mammae, are an exception to this general rule, since they usually give birth to more than one and often to as many as four or five young. More rarely litters of six or seven occur.

In some species the frequency of occurrence of extra mammae is much higher than in others. In the guinea pig variation from the normal pair is quite rare and has been recorded in the literature only once. The occurrence of one or two supernumerary mammae located on the milk line was reported in guinea pigs by Sollas.[1] These mammae existed in both males and females and in every grade of development from a bare circular skin patch to a pair of functional mammary glands. When unpaired, the supernumerary mamma was on the left side more often than on the right. The mode of inheritance of the character did not show either clear dominance or recessiveness. It appeared in the offspring of normal parents, and when two parents possessing extra mammae were mated they bore normal young as well as those having the character.

The purpose of this paper is to add to the meager information available concerning supernumerary mammae in the guinea pig. Special attention will be given to the distribution of the mammae on the body, to possible sex differences, to the effect on litter size. The mode of inheritance of supernumerary mammae will be discussed.

Materials and Methods

The data for this experiment were obtained from the records kept on guinea pigs in the Kansas Agricultural Experiment Station Genetics Laboratory. These records covered the period December, 1927 to June, 1940. The occurrence of supernumerary mammae was observed and recorded during an experiment in which the belly was checked closely for roan hair. Since this character was not handled as a regular experiment, the animals were not always examined for the presence or absence of accessory nipples, and when the matings were made this character was not taken into consideration. The litter records contained a diagram of each animal with notations on the sex and color, and with dots on the diagram showing the number and the location of the extra mammae. In order to study the mode of inheritance the offspring were observed from those matings in which one parent or both parents had supernumerary mammae.

Distribution of Supernumerary Mammae on the Body

The number of supernumerary mammae in our stock varied from one to five. In every case the extra mammae were located in the position of the embryonic milk ridge, anterior to the normal inguinal pair. When one accessory mamma was present it was located on one side or the other, with a greater number on the right side (Figure 9*A-B*). When two extra mammae occurred they usually were located on opposite sides. The pairs were located either at the same level of the milk line on each side (Figure 9*C*), or were asymmetrical (Figure 9*D-E*). In two cases both mammae appeared on the same side at different levels on the milk line (Figure 9*G*). When three extra mammae occurred, two of the nipples appeared in symmetrical pairs with the odd mamma on the right side (Figure 9*H*). Two nipples were located on each side in both cases where four accessory nipples were present (Figure 9*F*). In the one female with five extra mammae two were on the right and three on the left side (Figure 9*I*).

In most cases the accessory mammae were very rudimentary and in one animal it consisted of only a darkly pigmented spot. The supernumerary mammae were never found to be functional. There was no absence of hair

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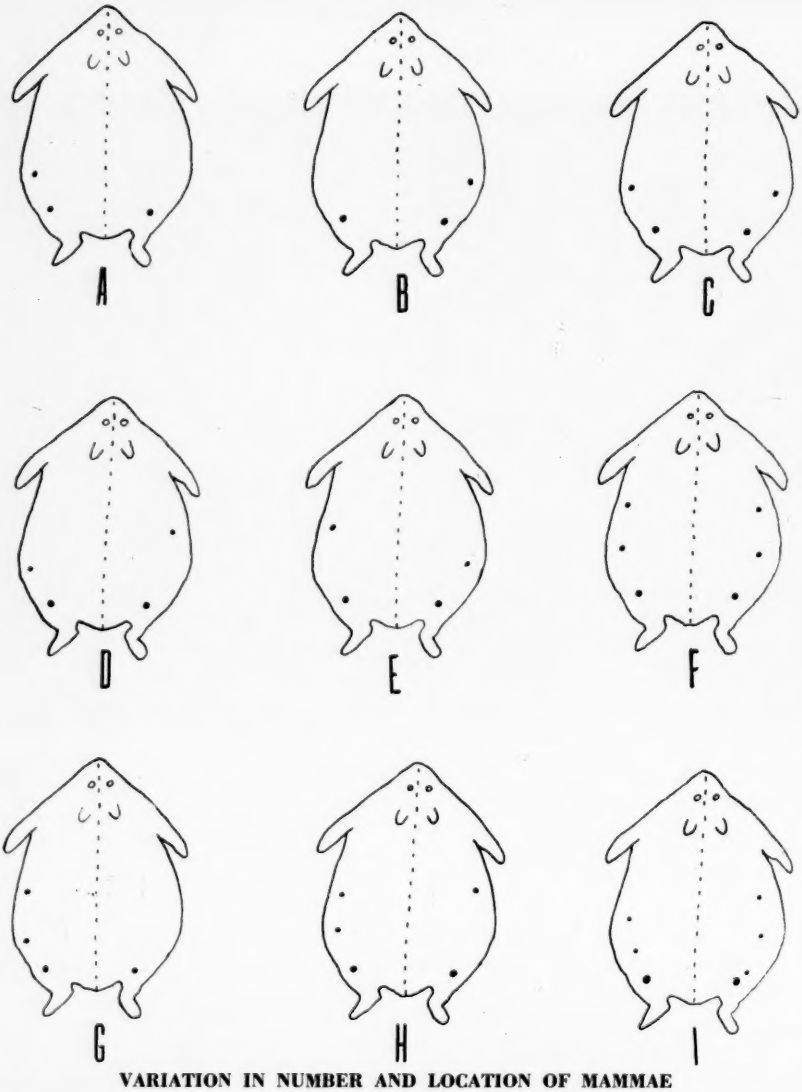

VARIATION IN NUMBER AND LOCATION OF MAMMAE

Figure 9

Diagrammatic drawings of ventral side showing the normal pair of mammae in the inguinal region, and the variation in location and number of accessory mammae on the milk line anterior to the normal pair. Those shown on the left side of the diagram were actually on the right side of the animal and vice versa. A single accessory mamma occurred on the right side (*A*) in 20 animals; on the left side (*B*) in three animals. A single symmetrical pair of accessory mammae occurred in six animals (*C*). Two animals had a single asymmetrical pair of extra mammae with the left mamma located anterior to the right mamma (*D*); and two animals had the mirror image of this pattern (*E*). One animal had four extra mammae occurring in symmetrical pairs, two on each side (*F*). Another animal had two accessory mammae present on each side, but the exact location was not indicated. Two animals had two accessory nipples, both on the right side (*G*). One animal had three accessory nipples with two occurring on the right side (*H*). One animal had five asymmetrically arranged supernumerary mammae (*I*).

NORMAL MAMMAE

Figure 10

A normal guinea pig showing the location of the single pair of mammae in the inguinal region.

in the immediate area of the extra nipple as is found in the normal pair (Figure 10), and it was impossible to observe the character unless an actual check was made. Most of the animals in the laboratory were not checked and for this reason the frequency of incidence in the population could not be determined.

In our extra-mammaed stock a single accessory mamma occurred in 58.7 percent of the total cases, two in 32.61 percent, three in 2.17 percent, four in 4.35 percent, and five in 2.17 percent (Table I). The exact location of the single supernumerary mamma was given on the diagrams for 23 of the 27 animals listed. Of these 23, 20 were present on the right side (Figure 9*A*) and three on the left side (Figure 9*B*), showing a significant difference. When the total number of supernumerary nipples recorded on the diagram is considered, there are 42 on the right and only 21 on the left side. These numbers again show a significant difference with a preponderance of mammae occuring on the right side. Sollas[1] also found a significant difference in the location of supernumerary mammae; however in her animals the mammae occurred more often on the left side. By totaling both groups of data there is found to be no significant difference in the occurrence of a single accessory mamma with regard to its location. Since each group of data separately shows a high deviation from the 50 percent expected by chance, but in the opposite direction, the justification for pooling the data seems a doubtful procedure. It may be possible that there is a difference in usage of the terms, right and left side. In this laboratory the mammae were recorded on the diagram as they appeared while looking at the animal ventrally; thus the mammae shown on the left side of the diagram were actually on the right side of the animal, and vice versa. A preponderance of mammae is shown on the left side of our diagrams.

Supernumerary Mammae and Litter Size

There has been a great deal of interest as to whether in some other mammals females with supernumerary mammae produce larger litters than are normally produced. A study was made in our stock to determine if there was an increase in litter size in cases where the female parent had supernumerary mammae. In guinea pigs first litters are smaller than the succeeding litters. Subsequent litters gradually increase in size, until the female approaches the end of fertility, when a decline in litter-size occurs. The first two litters that were born to females with supernumerary mammae were considered, since all of the fertile females with accessory mammae gave birth to at least two litters. Normal female parents were chosen at random from those contemporary females of the same age as the females with supernumerary mammae. In this way the effect of any seasonal difference or change in feed on litter size should affect the size of the litter from both the normal and the abnormal parents to the same degree, since they would be producing litters at approximately the same time. Two normal female parents were chosen at random for every abnormal female parent. When only the first two litters were considered, a total of 48 litters, the chi-square value was 5.19 with three degrees of freedom. The probability of such a high chi-square value happening by chance alone would be about one time out of six or seven. In order to get a larger number of litters for a more accurate test the first four litters were used, and one of the abnormal female parents that produced fewer than four litters was omitted along with the two corresponding normal parents of the same age. By using the

first four litters of both the abnormal and normals there was a total of 84 litters tested, 28 abnormal and 56 normal. A very low chi-square value of 2.18 with four degrees of freedom indicates no difference in litter size between those females with supernumerary mammae and those with the normal inguinal pair.

A possible explanation for any lack of correlation between the occurrence of supernumerary mammae and increased litter size may be due to the normal occurrence of plural births in guinea pigs even though they possess only a single inguinal pair of mammae. Since the litter size is already greater than would be expected with the normal number of mammae the addition of one or more mammae would have no effect on litter size.

Sex Differences

Supernumerary mammae also occurred in males. Out of 49 males examined within the experiment 21 had accessory mammae; 25 of the 46 females examined had the character. This does not show a significant sex difference. In both males and females a single accessory mamma appeared most frequently; 57.14 percent of the abnormal males had a single extra mamma, and 60 percent of the females (Table I). Nor was there a significant difference between the sexes in the occurrence of mammae on the right as compared with the left side. The average nipple number for the 25 females possessing supernumerary mamame was 1.64, and for the 21 males it was 1.52. Thus the accessory nipple number for the two sexes is not significantly different.

Mode of Inheritance of Supernumerary Mammae

Of the 46 cases of supernumerary mammae occurring in our laboratory, all but one can be traced back to one mating. The two original animals in this mating, however, are of unknown parentage, but they came from stock that was in the laboratory. It is possible, therefore, that all 46 animals have a common origin.

In every case in which an actual check could be made of the parents producing offspring with supernumerary mamame, at least one of the parents had one or more accessory nipples, which indicates that the occurrence of extra mammae is due to a dominant gene or genes.

When both parents had extra mammae, 26 offspring showed the character while 20 did not. When a male with accessory nipples was mated to a normal female six of the seven offspring examined had supernumerary mammae. When one parent had extra mammae and the other parent was one that had not been examined, 15 normal offspring were produced and three with the character (Table II).

The inheritance of the number of nipples or of the location of the nipples, whether on the right or left side, could not be determined with such a limited number of cases.

Discussion

The variation in number of supernumerary nipples in guinea pigs may be due to dosage effect; however, in our stock modifying factors are more plausible as an explanation for this variation. The dominant autosomal gene would, in this case, produce the abnormal character, but the number of extra nipples would depend on the modifying factors that were present. In Sollas's stock not more than two accessory mammae were reported. This can be explained by assuming that the plus modifying factors which were present in our stock were absent in hers.

Since none of the accessory mammae was functional in our animals it is quite possible that another gene is necessary for sufficient development of the glandular tissue to make the mamma functional. As previously stated, some of Sollas's animals had supernumerary mammae that secreted milk.

Summary

Supernumerary mammae occurred in 46 guinea pigs. The number varied from one to five, and in every case they were nonfunctional. All were located on the milk line anterior to the normal inguinal pair. They occurred equally in both males and females, and in both sexes a single supernumerary mamma

Table I. Frequency distribution of supernumerary mammae in guinea pigs possessing the character

SEX		NUMBER OF SUPERNUMERARY MAMMAE					TOTAL NO. OF ANIMALS
		1	2	3	4	5	
FEMALE	NUMBER	15	7	1	1	1	25
	PERCENT	60.00	28.00	4.00	4.00	4.00	
MALE	NUMBER	12	8	0	1	0	21
	PERCENT	57.14	38.10		4.76		
TOTAL	NUMBER	27	15	1	2	1	46
	PERCENT	58.70	32.61	2.17	4.35	2.17	

Table II. Number of offspring from matings in which one or both parents had supernumerary mammae. Showing those that were normal and those that possessed one, two, three, or four extra mammae.

PARENTS SHOWING ACCESSORY MAMMAE POSSESSED BY EACH ANIMAL		SEX	OFFSPRING NUMBER OF ACCESSORY MAMMAE					TOTAL
FEMALE	MALE		0	1	2	3	4	
1*	4*	Female	2	2	2	1		7
		Male	3	3	3			9
4*	1*	Female	4	1				5
		Male	3	2	1			6
0	4*	Female		3				3
		Male	1	1	2			4
2*	2*	Female	1	1	3			5
		Male	2	4				6
1*	2*	Female	1	1				2
		Male	4				1	5
?	2*	Female	4		1			5
		Male	7	1				8
4*	?	Female			1			1
		Male	4					4
2*	1*	Female		1				1
		Male						
TOTAL			36	20	13	1	1	71

* Number of accessory nipples present in each parent

was the most common type of variation. The single mamma occurred on both the left and right sides, but with greater frequency on the right side of both sexes. When two extra mammae were present, the position of the mammae on the body was variable, with both occurring on the right side, or one on each side in asymmetrical or symmetrical pairs. When three extra mammae were present, two were paired symmetrically with the odd mamma on the right. When four extra mammae occurred they always appeared in pairs, two on the left and two on the right side. Five supernumerary mammae occurred in only one animal, and three of these mammae were on the left with two on the right side.

The presence of supernumerary mammae in the female parent had no effect on the size of the litters she produced.

The hereditary factor for supernumerary mammae in guinea pigs is an autosomal dominant. In every case where the offspring showed supernumerary mammae at least one of the parents also expressed the character. It is quite possible that another gene, not present in our stock, is necessary for the development of glandular tissue in the extra nipples. The genetic basis for the wide variation in nipple number, one to five, could not be explained with the limited data in this experiment.

Literature Cited

1. Sollas, I. B. J. *London R. Soc. Rep. Evol. Comm.* 51-79. 1909.

(Received June 20, 1949)

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BASIC HORTICULTURE

THIS is primarily a text-book for the student who wishes to learn the fundamentals of horticulture, presumably with the objective of practicing one or more of the many branches of the industry. At the outset may we say that if the principles set forth in this work are thoroughly learned and digested and simultaneously an adequate application and demonstration of them carried out, the graduate will be fairly well launched as a successful beginner in his chosen field. There are of course thousands of relevant facts in nature and science having both direct and indirect bearings on plant life and its exploitation for human needs; it follows, as the author points out, that no one volume can tell the whole story, nor can a dozen or a hundred.

Yet the fundamentals or basic principles can be presented in abbreviated form, as is done in this text-book, giving the intelligent student a sound beginning in the broad field of horticulture, regardless of the particular type he may choose to follow. If the student is able to correctly solve the "problems" given at the end of each chapter, it is safe to say he has made a good start and is on his way to becoming a successful horticulturist. However this is but the beginning of his career, and now will come his self-training by investigation, observation, experiment and practice. The old rule of thumb days are over and the horticulturist must forever keep in mind that the applied science of horticulture has taken its place, and this again is interdependent on the science of botany. Space will not permit extended analysis or comment on the comprehensive list of subjects treated in 23 chapters. They cover the field quite broadly from production to consumption; they give specific information on plant structure and growth, climatic considerations, water, light and nutrient factors, propagation and culture practices and the control of insect and weed pests and other plant ills.

In the chapter on "Plant Nutrients as Limiting Factors" a fuller discussion on phosphate fertilizers would have been interesting and timely. In "The Valley and Its People," a story of the T.V.A., the remarkable results following a vastly increased use of phosphate concentrates is described. Vital nutrient problems will always be on the horticultural agenda and advances will constantly be made through scientific experimentation. Again a paragraph on the practice of "organic gardening," which is rapidly gaining attention, would no doubt have been appropriate and useful.

This book is supplied with many excellent and informative illustrations and a useful glossary of terms used in horticulture; it is well written and by no means pedantic. while the subjects are treated concisely and to the point. However, a most serious defect found in this book must be recorded, and that is the incorrect and unscientific terminology of a large proportion of the plants referred to. Without attempting to check all of the plant references over 40 errors were noted, covering both botanical and common names. A few typical examples are noted below.

**Basic Horticulture.* Victor R. Gardner. Revised edition 1951. The Macmillian Company. $4.75.

Page

11. *"Vaccinium pennsylvanicum"* is correctly *V. angustifolium laevifolium.*
12. "Shrubby mesquite (*Prosopis juliflora*)" is Honey mesquite, *P. glandulosa.*
17. "Japanese table pine" is Japanese red pine.
18. "Osage orange" is osageorange. It is not an orange and belongs to the mulberry family.
55. "Common juniper, (*Juniperus virginiana*)" is Eastern redcedar.
56. "several species of cypress—for example *Chamaecyparis obtusa* and *C. pisifera*"; these are not species of Cypress at all. They are respectively Hinoki Falsecypress and Sawara F. The only true cypresses are species and varieties of the genus Cupressus.
68. "Water chestnut (*Eleocharis tuberosa*)" is waternut. Chestnuts belong to the genus *Castanea.*
122. "African violet" (*Saintpaulia*) is in no way related to the violet. It is a ridiculous misnomer somewhat mitigated by compounding it as Africanviolet.
187. "Colorado blue spruce (*Picea pungens*)" *P. pungens* is Colorado spruce; *P. pungens glauca* is the blue Colorado spruce.
188. "Flamboyant (*Poinciana regia*)" is correctly Flamboyanttree, *Delonix regia.*
242. Malviscus is *Malvaviscus.*
282. "The Crotons (*Codiaeum variegatum*)." The crotons belong to the genus Croton. *Codiaeums* are the Leafcrotons.
291. "Blackberry (*Rubus nigrobaccus*)." *Nigrobaccus* is an obsolete botanical name. The plant referred to is Allegany Blackberry, *R. allegheniensis.*
302. "Satsuma mandarin (*Citrus nobilis*)." Satsuma orange is *C. nobilis unshiu:* Mandarin orange is *C. reticulata; Citrus nobilis* is the King orange.
345. "Shasta daisy (*Chrysanthemum frutescens*)." Shasta daisy is a form of *C. maximum. C. frutescens* is the Marguerite chrysanthemum.
351. "Paper birch (*Betula alba*)." The Paper birch is *B. papyrifera. B. alba* is an obsolete botanical name of the European white birch.
432. "Russian thistle (*Salsola pestifera*)" is Russianthistle, *S. kali tenuifolia.*

It is quite difficult to understand why the author of a text-book for students in horticulture should be so casual and incorrect in the terminology used. International Congresses and Committees are constantly working to bring order out of plant name chaos, both botanical terms and common names, and their findings are available. Unfortunately the horticultural press of America also is notably indifferent to adopting nomenclatural standards, and far too many horticultural tradesmen have little compunction in deliberately changing an established plant name in the hope of increased profit. Yet it is more ugaccountable to find a technical book for students filled with incorrect names of the very materials they are to study. Would not this fact suggest a speedy revision of the volume we have been considering if it is to serve as a standard text-book which its other qualifications entitle it to be?

The plant world has hundreds of thousands of plant species and varieties, and each year new varieties are being added by thousands. Will teachers, scientists and lexicographers continue to disregard the untold advantages of scientific standardized nomenclature? Bailey's New Manual of Cultivated Plants, Moldenke's American Wild Flowers, and Standardized Plant Names are all available to anyone who can grasp the importance of a standard orthography for plant names both common and botanical.

It is pertinent to quote the following from Moldenke's introduction: "In this book the orthography of the names is in general and with a few exceptions that recommended by the 1942 edition of Standardized Plant Names, published by the American Joint Committee on Horticultural Nomenclature. In the writing of the common names one rule recommended by the Committee but not universally honored in other books has been followed. A compound name that might be misleading in that it indicates a genus to which the plant does not belong is written as a solid or a hyphened word, for instance, Douglasfir, which is not a fir, or trailingarbutus, which is not an arbutus. Also many compound adjectives are written solid; longleaf, roundleaf, bighead, mealycup, and so on. Scientific names are italicized and the specific and subspecific parts lower-cased as recommended by the Joint Committee, and as is the practice among zoologists, geologists, and paleontologists, and the ever-increasing practice among younger botanists."

In the past throughout the plant world horticulturists, botanists and other scientists generally have been unaccountably unprogressive, and reluctant to adopt sane and logical standards in the field of plant orthography. As a result it is incontestable that progress in the plant world has been greatly impeded with consequent great losses to humanity. May we hope for early cooperative action to remedy this unfortunate situation.

HARLAN P. KELSEY
East Boxford, Mass.

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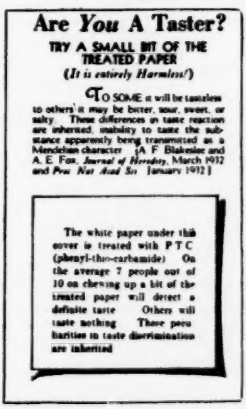
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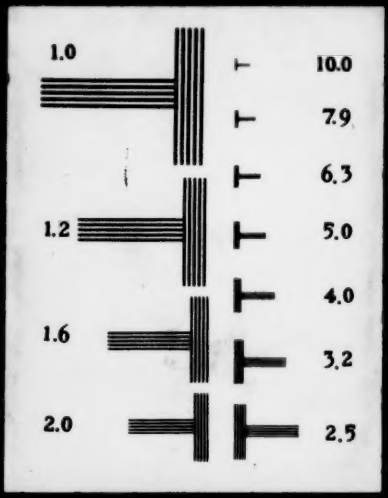

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